WINNIPEG, MB
APRIL 15TH – 17TH

13TH NORTH AMERICAN ARCTIC GOOSE CONFERENCE & WORKSHOP

2015

Program & Abstracts


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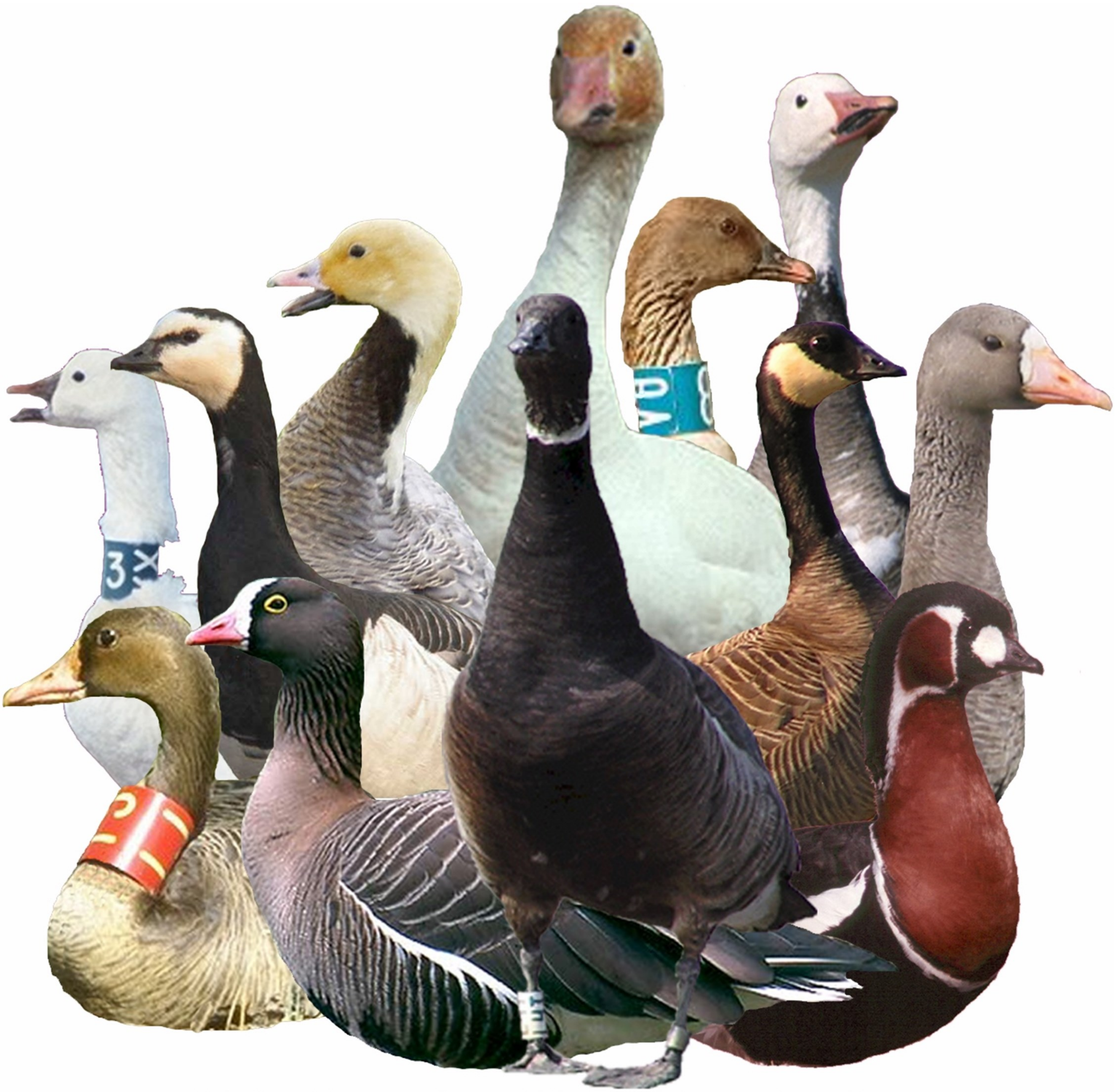

Tule, Ross', Barnacle, Lesser White-fronted, Emperor, Black Brant,
Greater Snow, Pink-footed, Lesser Snow, Cackling, Red-breasted, Greater White-fronted

NAAG 2015

We are pleased to welcome you to Winnipeg for the 13th North American Arctic Goose Conference! To our knowledge this is the second time that this meeting has been hosted in Manitoba. The last time was in 1989, when NAAGC6 was organized by Delta Waterfowl and held at the University of Manitoba Field Station at Delta Marsh - a lot has changed since then. First, the U of M Field Station was destroyed by a flood in the spring of 2011, when Lake Manitoba reached its highest water level since records have been kept. The Delta Waterfowl Research Station, a few miles down the beach, was also devastated by the 2011 flood. Delta Marsh was completely inundated by flood waters, and its boundaries temporarily expanded several miles southward as a result. Though devastating for local infrastructure, the marsh has since shown welcome signs of rejuvenation.

In 1989, the NAAG conference was a decidedly smaller gathering, and was almost entirely devoted to studies of snow geese and Ross's geese. The only departures from that theme were a talk by John Takekawa and Craig Ely about whitefront migration and wintering areas, and another by Jim Sedinger and Paul Flint based on their work on gosling growth rates of black brant. Also at that Delta conference, Alex Dzubin outlined the preliminary concept of an Arctic Goose Joint Venture (AGJV), which was later endorsed by the North American Waterfowl Management Plan Committee. In 2015, the AGJV is a mature, cooperative partnership that works to facilitate research and monitoring of all North American Arctic goose populations. The 6th NAAG Conference may have been small, but its impact is still evident today.

NAAGC7 was held in Vallejo, California in 1992, the first time the conference was hosted outside of Canada. This was the first attempt to greatly expand interactions among arctic goose researchers and managers from all over North America, and the tradition has continued ever since. NAAGC8 (1995) in Albuquerque focused on both breeding and wintering aspects of research and management, and held the first of many workshops that considered whether or not it was possible to have 'too many geese'. This theme continued at NAAGC9 (1998) in Victoria, and by NAAGC10 (2001) in Quebec City, the first evaluations of management actions to control overabundant goose populations were being considered. At more recent NAAG Conferences in Reno (2005) and Portland (2010), issues involving overabundant geese and climate change and their effects on habitat have continued to be front and center. Nonetheless, the diversity of topics considered at NAAGC continues to expand, and we look forward to a productive conference in Winnipeg!

Frank Baldwin
Jim Leafloor

NAAG 2015

General Information

Registration

You can register for the conference, pick up your registration package (*full conference program will be on supplied USB stick, highlights will be hard copy*), and obtain information at the registration desk. It will be located on the lower level of the hotel on the same floor as all conference and reception rooms, immediately outside the elevator doors. The registration desk will be staffed at the following times:

- Tuesday, April 14 from 4 PM to 9 PM
- Wednesday, April 15 from 7 AM to 1 PM
- Thursday, April 16 from 7 AM to 11 AM

Name Tags & Tickets

Your name tag is included in your registration package. It is your pass for admittance to all conference activities, and should be worn at all times. Separate tickets are included for those that registered for the banquet, and complimentary beverage tickets (beer, wine, and soft drinks) can be used at the opening and closing receptions. For those who have an invited guest, a name tag for the poster session and/or a banquet ticket will be included with your registration package with advance notification. For those who bought conference t-shirts, they are also included with your registration package.

Poster Session, Papers & Workshop

A Poster Session and barbeque are planned for the evening of April 15th, and will be held at the award-winning Oak Hammock Marsh Interpretive Centre (http://www.oakhammockmarsh.ca), located on the edge of a restored prairie marsh. Transportation will be provided.

Poster presenters should drop off their posters at the registration desk before noon Wednesday, April 15. Bus transportation to the poster session and barbecue will be provided, and will depart from the hotel at 5:15 PM. Return transportation by bus will depart the Interpretive Centre at 8:30 PM.

Presentations will take place in the Manitoba Room, in the lower level of the hotel. After the Poster Session at Oak Hammock Marsh, posters will be on display in the Saskatchewan Room (next to the Manitoba Room) for the duration of the conference.

Reception & Banquet

An opening reception will take place on Tuesday, April 14 from 6:00 to 8:00 PM in the Manitoba Room, downstairs from the front desk of the hotel. The closing banquet will be held on Friday evening, April 17 in the Manitoba Room. (Cocktails at 6:00, dinner at 7:00) The evening celebration will include local entertainers from Winnipeg's Aboriginal School of Dance.

NAAG 2015

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New Mexico Kansas
Oklahoma
Texas

Pacific Flyway Council

MEETING OVERVIEW

	Tuesday April 14	Wednesday April 15	Thursday April 16	Friday April 17
Morning		**Session 1:** **Population Biology** 08:20-11:50	**Session 3:** **Population Status and Conservation** 08:30-11:50	**Session 5:** **Migration** 08:30-11:50
Lunch **(11:50-13:15)**		*On your own*	*On your own*	*On your own*
Afternoon		**Session 2:** **Arctic Breeding Biology** 13:15-16:30	**Session 4:** **Snow Goose Ecology** 13:15-16:50	**Session 6:** **Nutrition** 13:15-16:40
Evening	**Opening Night Reception** Clarion Hotel 18:00-20:00	**Poster Session** Oak Hammock Marsh 17:15-21:00	*On your own*	**Banquet** Clarion Hotel 18:00-21:00

DAY 1 - Wednesday, April 15

8:20-8:35 **Welcome and Opening Remarks**
(Dave Duncan, CWS, and Co-chair, Arctic Goose Joint Venture)

Session 1: Population Biology

Session Moderator - Michael W. Eicholz

8:35-8:40 Plenary Introduction - Michael W. Eicholz

8:40-9:40 **Plenary: Humans, Nature, God and Dynamics of Goose Populations** - James Sedinger

9:40-10:00 **Effects of mate quality and pair-bond dynamics on rates of survival and breeding in black brant.**
Alan G. Leach*, James S. Sedinger, David H. Ward, W. Sean Boyd

10:00-10:30 **Refreshment Break**

10:30-10:50 **Spatial Heterogeneity in Population Trends of Geese Breeding on the Arctic Coastal Plain, Alaska.**
Courtney L. Amundson, Robert A. Stehn, Robert M. Platte, Heather M. Wilson, Julian B. Fischer, Paul L. Flint

10:50-11:30 **Integrated population modelling reveals a perceived source to be a cryptic sink**
Mitch D. Weegman*, Stuart Bearhop, Anthony D. Fox, Geoff M. Hilton, Alyn J. Walsh, David J. Hodgson

11:30-11:50 **Latent effects of initial maternal investment and quality on pre-fledging survival in black brant**
Thomas V. Riecke*, Alan G. Leach, and James S. Sedinger

** Student Presentation*

11:50-13:15 **Lunch Break**

Session 2: Arctic Breeding Biology

Session Moderator - Jean-Francois Lamarre

13:15-13:20 Plenary Introduction - Jean-Francois Lamarre

13:20-14:20 **Plenary: Goose, plant and predator interactions in arctic systems: how will climate change things?** - Gilles Gauthier

14:20-14:40 **High reproductive Success in Greater White-fronted Geese *Anser albifrons* on the Arctic Coastal Plain of Alaska.** Thomas F. Fondell, Brandt W. Meixell, Jerry W. Hupp, David H. Ward

14:40-15:00 **Is apparent nest success a useful metric of nest survival in colonial lesser snow and Ross's geese nesting at high densities?**
Dana K. Kellett and Ray T. Alisauskas

15:00-15:30 **Refreshment Break**

15:30-15:50 **Nesting by Canada Geese on Baffin Island, Nunavut.**
Jukka Jantunen, Anne C. MacLeod, James O. Leafloor, Kim T. Scribner

15:50-16:10 **Temporal trends and spatial variation in components of repro ductive success of Greater Snow Geese on Bylot Island.**
Cynthia Rezéndiz-Infante* and Gilles Gauthier

16:10-16:30 **Comparative Demography of Lesser Snow Geese and Black Brant on the Colville River Delta, Alaska.** Jerry W. Hupp, David H. Ward, Tyrone F. Donelly, Kyle R. Hogrefe.

** Student Presentation*

17:15-20:30 **Evening Poster Session at Oak Hammock Marsh Interpretive Centre**

DAY 2 - Thursday, April 16

08:30-08:35 **Announcements**

Session 3: Population Status and Conservation

Session Moderator - Ryan Zimmerling

08:35-08:40 Plenary Introduction - Anthony D. Fox

08:40-09:40 **Plenary: Status of Arctic-nesting Geese in North America.** James O. Leafloor

09:40-10:00 **50 Years of Collaborative Nēnē (Hawaiian Goose, Branta *sandvicensis*) Management: Where do we go from here?** Anne Marshall, Cathleen Natividad Bailey, Joy Tamayose, Darcy Hu, John Medeiros, Kathleen Misajon, Joey Mello, Thomas Kaiakapu, Hans Sin, Steve Kendall, Richard Switzer

***10:00-10:30* Refreshment Break**

10:30-10:50 **Taxonomic status and comparative phylogeography of Cackling Geese and Canada Geese.** Kim T. Scribner, Sandra L. Talbot, James O. Leafloor, Rainy I. Shorey, John M. Pearce, Scott Libants, Kevin Sage, Sarah A. Sonsthagen, Andrew Hope

10:50-11:10 **Testing a mechanism for species richness and latitude associations in waterfowl.** Michael W. Eichholz

11:10-11:30 **Integrating experiences from North America to attain the wise use of geese populations in Western Siberia.** Sonia B. Rozenfeld and George V. Kirtaev

11:30-11:50 **A global audit of northern hemisphere goose populations: status and trends.** Anthony D. Fox

***11:50-13:15* Lunch Break**

Session 4: Snow Goose Ecology

Session Moderator - Kiel Drake

13:15-13:20 Plenary Introduction - James O. Leafloor

13:20-14:20 **Plenary: What's up with midcontinent light geese? The perspective from Canada's central arctic.** Ray T. Alisauskas

14:20-14:40 **Assessing Competition by Cackling Geese and Lesser Snow Geese on Breeding Atlantic Brant.** Clark Nissley*, Christopher Williams, Kenneth F. Abraham

14:40-15:00 **Snow goose colony: a risky nesting area for shorebirds.** Jean-Francois Lamarre*, Gilles Gauthier, Pierre Legagneux, Eric T. Reed, Joël Bêty

***15:00-15:30* Refreshment Break**

15:30-15:50 **Tundra Vegetation Recovery: If, When & How.** Kathleen Schnaars-Uvino, Robert F. Rockwell, Robert L. Jefferies

15:50-16:10 **Indirect Effects of Geese on Arctic-breeding Shorebirds: What Do We Know?** Paul A. Smith, Scott A. Flemming, Lisa V. Kennedy, Erica Nol

16:10-16:30 **Plasticity in speed and timing of flight feather molt in the greater snow goose, a high-arctic-nesting species.** Vincent Marmillot*, Gilles Gauthier, Marie-Christine Cadieux, Pierre Legagneux

16:30-16:50 **Goose-vegetation relationships south of Queen Maud Gulf: cause vs. effect with implications for carrying capacity.** Ray T. Alisauskas

** Student presentation*

DAY 3—Friday, April 17

08:30-08:35 **Announcements**

Session 5: Migration

Session Moderator - Mitch D. Weegman

08:35-08:40 Plenary Introduction - Mitch D. Weegman

08:40-09:40 **Plenary: The influence of climate on goose migration ecology.** Anthony D. Fox

09:40-10:00 **Variation in Winter Location and Spring Migration Phenology of Black Brant: Implications for Timing of Arrival and Nesting of sub-Arctic and Arctic Breeders**. David H. Ward, Jerry W. Hupp, James Helmericks, Alan G. Leach, John Reed

***10:00-10:30* Refreshment Break**

10:30-10:50 **Predicted eelgrass response to sea level rise and its availability to foraging Black Brant in Pacific coast estuaries.** Frank Shaughnessey, Whelan Gilkerson, Jeffrey M. Black, David H. Ward, Mark Petrie

10:50-11:10 **Shifts in White-fronted Goose Use of Rainwater Basin Wetlands During Spring Migration.** Jeff Drahota

11:10-11:30 **The Importance of Pre-nesting Spring Staging Areas on the Interi or Yukon-Kuskokwim Delta for Populations of Geese, Swan and Crane.** Kyle A. Spragens

11:30-11:50 **Satellite transmitters and fall migration by snow and Ross's geese from Canada's central and eastern arctic.** Ray T. Alisauskas, Dana K. Kellett, James O. Leafloor

***11:50-13:15* Lunch Break**

Session 6: Nutrition

Session Moderator - Robert F. Rockwell

13:15-13:20 Plenary Introduction - Robert F. Rockwell

13:20-14:20 **Plenary: The bare essentials of avian physiology and nutrition: what every arctic goose biologist needs to know.** Scott R. McWilliams

14:20-14:40 **Parental quality and mate change affects growth and pre-fledging survival of black brant goslings.** Alan G. Leach*, James S. Sedinger, David H. Ward, W. Sean Boyd

14:40-15:00 **Daily Energy Expenditure of Black Brant during winter and spring along the Alaska Peninsula .** Bryan L. Daniels*, Jeffrey M. Black, David H. Ward

***15:00-15:20* Refreshment Break**

15:20-15:40 **Breeding and non-breeding birds do not differ in their proportion of time feeding or expenditure during spring migration.** Mitch D. Weegman*, Anthony D. Fox, Geoffrey M. Hilton, Alyn J. Walsh, Larry R. Griffin, Yehezkel S. Resheff, Ran Nathan, Stuart Bearhop

15:40-16:00 **Population reduction efforts and spring nutrition in midcontinent lesser snow geese.** Megan V. Ross*, Ray T. Alisauskas, James O. Leafloor

16:00-16:20 **Effects of disturbance vs. conservation measures on Pacific Black Brant (B. b. nigricans) fat deposition rates during spring staging.** W. Sean Boyd

16:20-16:40 **Ecological implications of reduced forage quality on growth and survival of sympatric geese.** Scott R. McWilliams, Samantha E. Richmann, James O. Leafloor, William H. Karasov

** Student Presentation*

List of Posters

1. Post-hatch movements of sub-arctic Canada geese (Branta canadensis interior). *Abraham, Pollock, Brook*
2. A meta-analysis of band reporting probabilities from waterfowl harvested in North America, 1944-2010. *Alisauskas, Sedinger, Arnold*
3. Demographics of stable or declining Lesser Snow Goose colonies. *Brook, Abraham, Rockwell, Koons*
4. Rapid Growth of a Lesser Snow Goose Colony on the Ikpikpuk River Delta, North Slope, Alaska. *Burgess, Ritchie, Person, Suydam, Shook, Prichard, Obritschkewitsch*
5. Increases in Exposed Peat from 1992 to 2010 in association with increased light goose populations in the Queen Maud Gulf Bird Migratory Sanctuary. *Conkin, Alisauskas*
6. Survival and Fidelity of Atlantic Brant Banded on Southampton Island and Baffin Island, Nunavut, 2000-2011. *Dufour, Castelli, Dickson, Leafloor, Meeres*
7. Lesser Snow Geese in Wapusk National Park: a hyperabundant problem? *Gibbons, Ouimet, Rockwell*
8. Comparisons of Hunting Season and Light Goose Conservation Order Participation and Harvest in the Central and Mississippi Flyways, 1999-2014. *Johnson, Vrtiska, Murano, Kruse, Fronczak*
9. Annual Survival of Lesser Snow Geese Marked on the Ikpikpuk River Colony, North Slope, Alaska. *Person, Nicolai, Ritchie, Suydam, Burgess*
10. Tule Geese in the Muddy Lakes: helping track molting geese in a remote region of the Yukon Delta NWR. *Spragens*
11. Predicting Effects of Environmental Change on a Migratory Herbivore. *Stillman, Wood, Gilkerson, Elkinton, Black, Ward, Petrie*
12. Emigration of sympatric Ross's and Snow Geese from the central North American Arctic: the roles of prior breeding success, environmental conditions and abundance. *Wilson, Alisauskas, Kellett*
13. Midcontinent greater white-fronted goose distribution and migration chronology: A study using advanced satellite telemetry. *Askren, Osborne*
14. Building a Predictive Model of Submerged Aquatic Vegetation Prevalence for Atlantic Brant Using Remote Sensing and In Situ Sampling. *Colmorgen, Williams*
15. Activity Budgets of Black Brant on the Alaska Peninsula during Winter and Spring. *Daniels, Black, Ward*
16. Evaluating the Large-Scale Effects of Geese on Other Tundra-Nesting Birds. *Flemming, Smith, Nol*
17. Body condition of lesser snow (Chen caerulescens caerulescens) and Ross's Geese (C. rossii) harvested by different methods during the Light Goose Conservation Order. *Fowler, Vrtiska, Webb*
18. Comparisons of condition, hematocrit, egg volume, clutch size and nest success of arctic-breeding shorebirds on two Arctic islands with and without snow geese. *Kennedy, Smith*

List of Posters

19. A Preliminary Assessment of the Role of Interior Spring Staging Areas and Acquisition of Berries in Influencing Pre-Breeding Condition of Cackling Geese on the Yukon Delta NWR. *Moore, Spragens*

20. Assessing Competition by Cackling Geese and Lesser Snow Geese on Breeding Atlantic Brant. *Nissley, Williams, Abraham*

21. Do individual heterogeneity and age structure limit the reproductive potential of goose populations? *Riecke, Leach, Sedinger*

22. Ecological effects on midcontinent light goose recruitment. *Ross, Alisauskas*

23. Fitness costs and benefits of prolonged parent-offspring and sibling-sibling associations in an Arctic-nesting goose population. *Weegman, Bearhop, Hilton, Walsh, Weegman, Fox*

24. Aerial Detection of Incubating Geese in an Open-Tundra Habitat. *Sharp, Abraham, Leafloor, Roetker*

25. Assessing Habitat Change at East Bay, Southampton Island: 1979 to 2010. *Abraham, Sharp, Kotanen*


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13th Annual North American Arctic Goose Conference

Plenary Speaker Information

Dr. Scott McWilliams

Scott McWilliams is a Professor of Wildlife Ecology and Physiology in the Department of Natural Resources Science at University of Rhode Island. Prior to coming to URI, he was a Postdoctoral fellow at University of Wisconsin (Madison). He earned his PhD from University of California at Davis where he studied the physiological ecology of arctic-nesting geese, and his MSc from Iowa State University where he studied the behavioral ecology of a threatened species of salamander. Scott earned his BSc in Biology from Hiram College (Ohio). His research primarily focuses on the nutrition, physiology, and ecology of wild vertebrates, with an emphasis on migratory birds of conservation interest. Current research topics include habitat use, diet, and nutrition of arctic-nesting geese, sea ducks, and migratory songbirds; forest management to support healthy bird populations; exercise physiology of long-distance migratory songbirds; effects of climate change on migratory birds; how offshore wind farms affect migratory birds.

Dr. Tony Fox

Tony Fox is actually British but has lived in Denmark for the last 22 years, where he is employed at the Department of Bioscience at Aarhus University. For his Ph.D he studied raised mire hydrology, but constant immersion waste deep in soft peat and two (drier) ornithological expeditions to west Greenland convinced him waterfowl ecology research offered a more interesting if less certain career. He has a visiting position with the Chinese Academy of Sciences in Beijing where he has worked closely with Professor Cao Lei on East Asian flyway waterfowl ecology since 2008. Although his professional focus continues to be arctic geese (especially his beloved Greenland White-fronts!), as well as migratory ducks in NW Europe, he has just started a study on Taiga Bean Geese and has also had the great privilege to work with Hugh Boyd, Bob Bromley and Ray Alisauskas in the Canadian Arctic in the early 1990s.

Dr. Gilles Gauthier

Gilles Gauthier has been professor of animal ecology at the biology department and at the Centre for Northern Studies of Université Laval since 1987. He holds a BSc in biology from Université de Montréal (1979), a MSc in biology from Université Laval (1982) and a PhD in zoology from the University of British Columbia (1985). His research is focused on the population biology of birds, primarily waterfowl and birds of prey, mainly in the Arctic. He is interested in demographic processes (reproduction, survival, dispersion, recruitment) responsible for changes in population abundance and their ecological determinants. He is also interested in the dynamics of the tundra food web, the trophic interactions (herbivory, predation) that control it, and how climate warming is impacting these interactions. These questions are addressed through long-term studies of animal populations in the field, mainly in the Canadian Arctic. Several of his projects address problems of interest for the management of exploited wildlife populations and the conservation of species and ecosystems. His longest running project has been the population study of the greater snow goose on Bylot Island, now entering its 28th year. This project has embraced a wide variety of topics over the years, including reproductive strategies, demographic processes, feeding ecology, migration, plant-herbivore and predator-prey interactions and impact of hunting and climate change. Results of this long-term study have been used to design management policies for snow geese and to evaluate their effectiveness in achieving their goals and also as a model for management decisions in other goose populations.

Dr. Ray Alisauskas

Ray Alisauskas grew up in Montreal by the St. Lawrence River, where he fished and watched ducks as a little kid. Motivated by an interest in outdoor life, camping and an innate attraction to wetlands, he completed a diploma course in wildlife management in 1976. He studied energy and nutrition of birds with Dave Ankney at the University of Western Ontario, where he completed an MSc (1982) about American coots, the same year he embarked on a PhD about nutrition of midcontinent snow geese during spring migration. During his time in Ontario, Ray spent much time near the marshes of Long Point and bays of Lake Erie to be closer to the large numbers of diving ducks there each fall. Following his PhD (1988), Ray received a postdoctoral scholarship during which he spent time at Delta Marsh, and then was employed as a Research Scientist with Canadian Wildlife Service in Saskatoon (1989). In that same year, Ray organized the Snow Goose Conference at Delta, Manitoba. In 1991, he joined the Department of Biology, University of Saskatchewan, as adjunct professor. He has continued his long term research on spring nutrition of snow geese, and has expanded it to include Ross's, cackling and White-fronted geese during migration through Saskatchewan. He initiated long-term research on population biology of Ross's and snow geese at Karrak Lake in Canada's central arctic (1990), and expanded research there to include long-term population studies of King Eiders (1995) and Long-tailed ducks (1998). Ray has also retained a focus on population biology of White-winged scoters in Saskatchewan.

Dr. Jim Leafloor

Jim Leafloor spent his formative years in southern Manitoba, growing up in Portage la Prairie, near Delta Marsh. He was introduced to snow goose hunting by Alan Panko in 1977, and this was the beginning of a life-long friendship and fascination with geese. Though their efforts to control the growth of midcontinent goose populations have not been entirely successful to date, Jim and Al continue to evaluate new and improved approaches to hunting and preparing their favorite prey species for the table. Jim received his M.Sc. from the University of Western Ontario (1989), where he benefitted greatly from the supervision of his mentor and friend, Dave Ankney. Jim began his professional career as a Waterfowl/Marine Mammal biologist in 1990, and spent 12 years working mainly on geese in the Hudson Bay Lowlands of Ontario for the Ministry of Natural Resources. He completed his Ph.D. with Don Rusch at the University of Wisconsin-Madison in 1998, studying the genetic, environmental, and behavioral factors associated with geographic variation in body size of Canada geese. Jim has been a waterfowl biologist with the Canadian Wildlife Service in Winnipeg since 2002, and the Canadian co-chair of the Arctic Goose Joint Venture Technical Committee since 2009. His main professional interests include population ecology and management of geese, and he remains particularly obsessed with all aspects of taxonomy and geographic variation in white-cheeked geese.

Dr. Jim Sedinger

I was very lucky when Dennis Raveling (Rav) agreed to take a chance on an electrical engineer with no field experience and took me on as a student in December 1976. The next May, Rav, Craig Ely and I were dropped off at Old Chevak (a historic catholic mission on the coastal tundra of the Bering Sea) at about midnight the first week of May. Three field seasons studying Cackling Geese, two with my beautiful wife, Connie, ensued. The next several years in the ideas cauldron of the Raveling lab were wonderful, as were the all-night sessions in Rav's hotel room at numerous conferences. I was lucky again, when the "goose crisis" in southwest Alaska led to new positions at what is now the Alaska Science Center, and I got my wish to work on a brant colony, where I believed (based on the success of the La Perouse Bay study) we could generate sample sizes necessary to understand evolution of life-histories in geese. I was lucky again, when my predecessor at the University of Alaska Fairbanks resigned his position while I was in Anchorage and I successfully competed for a faculty positon in Fairbanks. My luck continued when the first two graduate students to work on the Tutakoke River brant study were motivated, hardworking individuals (who have gone on to successful careers) that put the project on a successful path that continues to this day. These two established a culture of hard work and comraderie that continues to the present. They were the first in what grew to be 15 students that worked on the Yukon-Kuskokwim Delta and 15 others that have worked in other systems. These students have had a profound effect on my personal and professional life. Numerous times my career has taken a turn because of what I learned from my students and I count myself as incredibly lucky to have been associated with them.

Abstracts - Papers

Contributed Papers

Abstracts are arranged in alphabetical order by primary author. Abstracts were reformatted but otherwise printed as provided by authors except for minor editing style and syntax. Information contained herein should NOT be cited without first obtaining author approval.

(denotes student papers)*

Goose-vegetation relationships south of Queen Maud Gulf: cause or effect?

Ray T. Alisauskas, Science and Technology Branch, Environment Canada, Prairie and Northern Wildlife Research Centre, 115 Perimeter Road, Saskatoon, SK, S7N 0X4, Canada. Email: Ray.Alisauskas@ec.gc.ca

At the same time that adult survival rates of midcontinent snow geese have increased to exceptionally high levels, there has been a long term decline in harvest age ratios, and an attenuation of population growth. This suggests that density-dependence may be governing recruitment, perhaps through a reduction in per capita forage availability on the breeding grounds. I examined forage quality, availability, and use in lowland habitats used by snow geese in the central arctic of Canada. To do this, I randomly deployed 50 1x1 m exclosures within a stratum of lowland tundra habitats in the Queen Maud Gulf Migratory Bird Sanctuary (QMGMBS, ~63,000 km2) in August 2013. Distinct from drier heath and rocky habitats in uplands, lowland tundra included wet sedge meadows, hummock and tussock graminoid tundra. Vegetation coverage was measured at 1 m intervals along a 50 m transect outside of exclosures, and the number of goose droppings was counted within a 25 m2 quadrat adjacent to each exclosure. Exclosures were revisited in August 2014, when vegetation height was measured, and above ground vegetation was clipped from 0.1 m2 plots inside (a measure of net above-ground primary productivity) and outside of each exclosure (the difference from inside providing a measure of vegetation removed by grazing herbivores over the preceding growing season). Long term exclosures were used to examine annual changes in habitat characteristics, and to relate goose foraging activity to changes in vegetation characteristics over time. Results suggest that while some lowland habitats are intensively used by geese, productivity and carrying capacity of the habitat remains high. At the same time, large expanses of what appears to be suitable lowland tundra habitat remain unoccupied by light geese, at least in the QMGMBS.

Satellite transmitters and fall migration by snow and Ross's geese from Canada's central and eastern arctic.

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We deployed 10 GPS satellite transmitters (PTTs) on adult female snow geese at each of Baffin Island, Southampton Island, and south of Queen Maud Gulf (QMG) in 2014, with 5 mounted on neckbands, and 5 mounted on the back with Teflon tape harnesses at each site. Also, we deployed 10 backpack PTTs of the same design on 10 adult female Ross's geese at Queen Maud Gulf. Snow geese left Baffin Island 2 September ± 3.9 days (95% CL), and most staged in the arctic tundra, i.e., above the treeline, of northern Quebec until 18 September ± 5.5 days. Most then flew SW directly over Hudson Bay and coastal marshes of northern Ontario, but only 3 of 7 landed near the coast (range 1.5 to 39 km inland) and staged there only 5 ± 4.4 days before flying non-stop to prairie Manitoba arriving there 25 September ± 4.6 days. Snow geese from Southampton Island were non-breeding females that departed the island 22 August ± 4 days, and flew west to the rocky mainland barrens, continuing to travel slowly SW ~100 km inland and parallel to the Hudson Bay coast. They departed arctic tundra on 8 September ± 1 day, spent two days in taiga habitat, departed from there on 10 September (± 1 day), and flew non-stop over the boreal forest, arriving on the prairies of Saskatchewan on 11 September ± 2 days. Snow and Ross's geese from QMG departed the tundra on 9 September ± 3 days, used taiga habitat until 13 September ± 3 days, and arrived in prairie Saskatchewan on 11 September ± 3 days. The average departure date from southern Saskatchewan was 12 November ± 3.4 days, with mean arrival in the Mississippi Alluvial Valley (MAV) on 13 November ± 3.8 days, where all surviving marked snow geese settled for at least a portion of the winter, in either Arkansas or Mississippi. No geese travelled to Texas or Louisiana. In summary, from 1 August geese spent 42.2 days in the arctic, 2.4 days in taiga, 0.4 days in boreal and 59 days in prairie habitat. Most time on the prairies was spent in Canada (54 days), and only 2 and 3 days in North and South Dakota, respectively, and these were mostly Baffin Island geese. Compared to earlier descriptions of fall migration by snow geese, when most staged on the coasts of James and Hudson Bay from early September to mid-October, there was little use of these habitats by midcontinent snow geese during autumn. Instead of a non-stop flight from these marshes to those in coastal Louisiana, snow geese relied heavily on agricultural lands in prairie Canada and the MAV. Use of arctic habitats was important before southward migration to the prairies, while boreal and taiga habitats were little used.

Spatial Heterogeneity in Population Trends of Geese Breeding on the Arctic Coastal Plain, Alaska

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Breeding goose populations on the Arctic Coastal Plain (ACP) of Alaska are growing rapidly. U.S. Fish and Wildlife Service aerial surveys conducted since 1986 suggest breeding pair density of greater white-fronted geese (*Anser albifrons*), Pacific black brant (*Branta bernicula nigricans*), and lesser snow geese (*Chen caerulescens caerulescens*) are increasing approximately 8% , 7%, and 25% per year, respectively. However, populations have not increased uniformly across the ACP but, to date, the direction and magnitude of spatial heterogeneity in population trends remain unclear. We evaluated aerial survey data from 1992–2014 using Bayesian hierarchical Poisson state-space models to 1) estimate population trends within 15 km x 15 km grid cells across the ACP, 2) evaluate habitat and environmental associations of breeding geese, 3) examine whether the onset of 'green-up' derived for each cell in each year was associated with abundance and population trends, 4) evaluate inter-specific competition between brant and snow goose abundance in mixed-species colonies, and 5) explore possible density-dependence in population trends. Analytical methods used in this analysis improved upon previous estimates by controlling for multiple sources of sampling variance (e.g., observers, survey timing) and allowing extrapolation to unsurveyed areas, and methods are applicable to aerial survey data collected elsewhere. Preliminary results suggest greater white-fronted geese, the most common waterfowl species breeding on the ACP, are increasing substantially along the northern coast of Alaska, especially from Barrow east to Teshekpuk Lake, and are decreasing or stable inland and farther south. The probability of occupancy of small black brant colonies has increased through time, especially along the northern coast of the ACP, but factors associated with years-occupied are still being evaluated. Virtually non-existent on the ACP before 1999, lesser snow goose populations are now largely restricted to colonies on the Ikpikpuk and Colville River deltas, but small colonies along the coast have also increased in recent years. Our initial results suggest that increasing numbers of geese are breeding along the northern coast of the ACP; a finding concordant with recent research documenting an abundance of high-quality salt-marsh sedge forage and rapid growth rates of goslings hatched near the coast. Only black brant seem to be experiencing more moderate positive population growth rates in recent years. Overall, our results suggest populations of all three species will continue to increase, especially along the northern coast.

Dynamics and changes in the population structure of Wrangel Island snow geese

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Many species of arctic geese wintering in North America and Europe have dramatically increased in numbers. This has primarily been attributed to changes on wintering grounds and migration routes, but in the case of Wrangel Island snow geese (WISG), changes on the nesting grounds have been more important. During the past 50 years, the WISG population declined significantly in the 1970s but increased to about 155,000 in 2011, the last year that surveys were conducted on Wrangel Island. The recent increase in this population is due to reduction of predation pressure on the Tundra River colony and general warming patterns of the arctic and sub-arctic. These two factors result in lower energy costs for breeding individuals and as a consequence, more favorable conditions for recruitment. At the same time, sharp decreases in natural selection by predators have led to an increase in the frequency of productive seasons, as well as changes in population structure and behavior. The ratio of Wrangel Island arctic foxes to snow geese nests decreased tenfold (from 1:500 to less than 1:5,000), and foxes on Wrangel Island and in many areas of the Arctic are no longer a limiting factor for snow geese. As a result of the change in age structure, the population has become more mobile and expanded its distribution. At this stage, the conditions and capacity of habitat on wintering and migratory routes play a major role in maintaining the numbers of this population. For management of light geese in this new environment where they are overabundant, we need to find mechanisms that could reduce the productivity of the colonies, by reducing the energy resources of birds in spring and increasing energy costs during the nesting season. One of the methods that could be explored is the use of disturbance in nesting areas (e.g. flushing birds from nests using hazing techniques, possibly including falconry raptors). Disturbance during incubation is very costly energetically and purposefully using such disturbance could significantly reduce the productivity of the colonies. A reduction in the productivity of the colonies for 2-3 years could have some effect on the size of these populations. We think that disturbance during the nesting season may prove to be cost-effective in comparison with other methods of direct influence on the colonies of light geese.

New insights on the migration of Wrangel Island snow geese

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Despite the fact that we have learned much about the population of snow geese breeding on Wrangel Island, Russia in recent decades, we still know little about migration of this population, especially during spring. Geese nesting on Wrangel Island winter mainly in two fundamentally different areas: British Columbia / Washington State and California. Opening of spring hunting in Alberta has posed additional threats to the status of Wrangel Island Snow Geese (WISG), and the need for new data on the migration through these areas has increased. In 2013, we initiated a project with satellite marking of WISG in Washington (northern wintering area). We implanted transmitters (Telonics TAV-2630, 35g) in 10 adult female snow geese. From these 10 transmitters, we received data from 7 and were able to track annual cycles plus another spring migration. The transmitters provided valuable information on habitat use during migration, especially for Alaska. For the first time we were able to document a previously unknown migration strategy: WISG flying directly from Alaska to Wrangel Island, covering a distance of more than 800 km per flight. In addition, we found that WISG covered more than 1500 km over the ocean from Alaska during fall migration. We have also seen a closer connection between the northern population of WISG and the Canadian prairies during spring migration than previously thought. One bird migrated from the Fraser River Delta to Alberta and then on to Wrangel Island, presumably with geese migrating from California. Recently, because of the increasing numbers of Western Arctic snow geese, changes in management have necessitated initiation of a new international joint project to mark snow geese in different breeding areas, including Wrangel Island, Banks Island, and the North Slope of Alaska.

Effects of disturbance vs. conservation measures on Pacific Black Brant (*B. b. nigricans*) fat deposition rates during spring staging

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Parksville-Qualicum on the east coast of Vancouver Island, British Columbia, is an important spring-staging site for Pacific Black Brant (*Branta bernicla nigricans*) on their way to breeding grounds in Alaska and beyond. In 1999 we began recording the abdominal profile index (API) of marked individuals to estimate the mean rate of fat accumulation each spring. The mean rate declined significantly from 1999 to 2004, to the point where Brant did not build reserves at all in 2004. However, the rate increased again in subsequent years and by 2009 recovered to the same high level as in 1999. This recovery corresponded to a specific conservation measure initiated in 2003 (but not rigorously enforced until 2005), namely the prohibition of dogs on key beaches during the core staging months of March and April. Average rates of disturbance to Brant prior to the conservation measure being implemented were among the highest recorded globally, causing up to 3.5 avoidance flights per hour. Eagles were responsible for roughly 60% of the disturbances and humans (plus dogs) only about 35%. The finding that fat accumulation rates increased once dogs were removed suggests that they may have been negatively affecting Brant time/activity budgets and inhibiting access to important foods such as eelgrass, algae, and even (ephemeral) herring eggs. If this scenario was allowed to continue Parksville-Qualicum could have become energetically unprofitable for the Brant, causing them to eventually abandon the site altogether. At the local scale, conservation efforts should continue to control dog access to this and other important spring-staging sites along the Pacific Coast. In addition, we need to understand the relationships between individual staging variables, such as the timing of migration and length of stay, and; 1) body condition (e.g., API levels), 2) food abundance and availability, 3) rates and sources of disturbance, and 4) annual survival and reproductive rates. More broadly, the spring migration strategies of Brant should be examined within a greater Pacific-wide context.

Age structure in the demographic vital rates of sub-Arctic breeding Canada Geese

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The effect of age or breeding cohort structure on demographic vital rates in goose populations can have implications for the efficacy of population models. Population models that more closely reflect the true structure related to the underlying vital rates can lead to improved harvest management and increase our knowledge of breeding biology and life history. Using a long-term banding dataset and incorporating information from recaptures and band returns, we tested hypotheses concerning patterns and influences of survival for a known aged sample of Canada Geese on Akimiski Island, Nunavut. We found that gosling size had a positive influence on the first year survival of juveniles though there was additional annual variation in the estimates for which gosling size alone did not account. Further, we found that body size of known age adult Canada Geese was related to the mean hatch cohort gosling size but we found no detectable influence of gosling size beyond survival in the first year. Therefore, we believe that selection against smaller (presumably weaker) Canada Geese occurs prior to their entering the breeding population at two years or older. Models that estimated survival as a function of hatch-year cohort (independent of gosling size) were not competitive with models that estimated survival as a function of age and year. There was indication that survival of Canada Geese from first to second year was different from the survival rate of adults two years or older though there was overlap in those rates. We found that models incorporating both band return and recapture information greatly improved precision on survival estimates compared with estimates produced using band return data alone. Our findings confirm the vital rate structure necessary for parameterizing more accurate population models.

Daily Energy Expenditure of Black Brant during winter and spring along the lower Alaska Peninsula

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Breeding success in northern-nesting geese is dependent on nutrient reserves acquired at spring staging sites. Prior to migration to breeding sites, geese must deposit body stores of fat, protein, and minerals, which are metabolized to complete spring migration, form eggs and fuel incubation. Black brant (*Branta bernicla nigricans*) have one of the most specialized diets of geese outside of the breeding season, utilizing coastal habitats to feed on intertidal eelgrass (*Zostera marina)*. The lower Alaska Peninsula with the largest eelgrass bed in the Pacific Flyway is a key spring staging site and an increasingly important over-wintering location for black brant. Past studies suggest that black brant may not reach their daily energetic requirements during diurnal foraging and must utilize other methods to acquire enough nutrients. To determine the daily energy requirements for black brant along the lower Alaska Peninsula, we calculated the daily energy expenditure in Kinzarof and Izembek lagoons during winter (February-March) and spring (April-May). Daily energy expenditure summed the energetic costs of daily time-budgets, flight times, and nocturnal activity. Flight costs accounted for the greatest amount of expended energy in winter and spring. Roosting and cost of thermoregulation were the next most energetically expensive activities during winter, followed by foraging and vigilance during spring. Variation in the energy expenditure was most influenced by the amount of time flying due to the spatial distribution and availability of food resources between seasons. This study of energy expenditure allows us to better understand and determine the ecological requirements for black brant during winter and spring in Alaska.

Shifts in White-fronted Goose Use of Rainwater Basin Wetlands During Spring Migration

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The mid-continent population (MCP) of greater white-fronted geese (*Anser albifrons*; WFGO) nest across most of the central and western. This population congregates in west-central Saskatchewan in large numbers each fall, winters in Arkansas, Louisiana, Texas, and northern Mexico. In the spring, an estimated 90% of this population uses the Rainwater Basin (RWB) area in south-central Nebraska as a mid-latitude stopover area. Survey effort during spring migration has varied dramatically over the last 56 years making it difficult to assess any changes in staging abundance. From 1956-1993, a low-level aerial Coordinated Spring Survey (CSS) was completed each spring with the addition of ground surveys in 1977, all were used to estimate MCP WFGO populations. However, in 1993, the aerial portion of this survey was terminated due to increased bird-strike potential coinciding with increased light geese numbers across the region. Ground surveys continued, but the methods changed with conflicting priorities to monitor light goose populations within the region. I normalize data across years from various survey techniques to determine WFGO abundance trends. All survey data provided an arrival week, a mean population each week over an 8 week survey period, and therefore a peak abundance week could be determined using individual wetland counts and using a polynomial equation to generate abundance curves. Regardless of survey bias, reviewing the distribution of abundance data as a mean each week provides a general measure of abundance over time. During 1998-2007, these estimates declined by an average of 5% per year ($P = 0.059$, USFWS 2008). Ground survey data from 2000-2013 indicate significant declines ($F = 23.15$ $P = <0.0001$) in recent years where mean WFGO abundance in 2000 was 584.0 birds/wetland and in 2013 was only 22.5 birds/wetland. It is clear that WFGO use of RWB wetlands is significantly less that it was historically, but the reasons for this change are less clear. Drought in recent years has reduced available habitat that may have contributed to reduced use, but the Conservation Order may also be contributing to WFGO distribution changes that the RWB have experienced. In fact, WFGO use was significantly less on wetlands that were open to hunting during the Conservation Order ($F = 21.57$, $P = <0.0001$). Yet, given that MCP is stable, the RWB may not be a critical stopover habitat for WFGO as previously thought because they apparently have found suitable stopover habitat elsewhere.

Testing a mechanism for species richness and latitude associations in waterfowl

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Species richness is determined by the number organisms with overlapping distributions. Understanding the mechanisms that cause variation in species richness has been of interest to ecologists for decades. Species richness of most taxonomic groups decreases with increasing latitude. Multiple mechanisms have been proposed to explain this relationship (e.g., time or rate of diversification, niche conservatism, ambient energy, habitat heterogeneity, resource availability, species area relationships), however, a consensus as to which of these factors most often drives this relationship has not been achieved. One way to better understand the driving mechanism of this relationship may be to evaluate organisms that do not follow the typical relationship. The order Anseriformes (waterfowl) is a taxonomic group that displays an atypical pattern in that species richness increases with latitude to a peak in temperate and sub-arctic regions then declines in more northern arctic regions. Nearctic geese, a component of this taxa show a similar pattern. The northern limit for most species is likely due to the lack of an ice free period adequate to allow for the successful completion of reproduction. The mechanism for limiting the southern distribution is less clear. Dalby et al. 2014 recently concluded degree of seasonality best explained the species richness of worldwide breeding waterfowl. Seasonality could influence species richness by influencing the ability of waterfowl to acquire nutrients. A number of studies have found vegetation from more seasonal latitudes is more digestible. Thus, nutrient availability from vegetation in less seasonal environments may be inadequate to support growth of young geese. We tested this hypothesis by comparing growth rate of Canada geese (Branta Canadensis) nesting in northern and central Illinois, a region where Canada goose populations thrive, to gosling growth in southern Illinois, a region where Canada goose population are small but persistent. We found goslings in southern Illinois grow at a significantly slower rate than goslings in more northern regions of Illinois or gosling from Akamiski Island during a period when gosling were knows to be nutritionally limited. These results are consistent with the hypothesis nutritional limitations of forage limit the southern distribution of breeding Canada geese and may explain the decline in species richness of waterfowl in lower latitudes.

High reproductive Success in Greater White-fronted Geese *Anser albifrons* on the Arctic Coastal Plain of Alaska

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The abundance of greater white-fronted geese (Anser albifrons) breeding on the Arctic Coastal Plain of Alaska (ACP) has more than tripled since the 1990s, and the rate of increase is climbing. In contrast to other Northern Hemisphere geese, where adult survival has been the major driver of population dynamics, population increase on the ACP may be driven by changes in reproductive success. To assess this hypothesis we examined clutch size, nest success, and gosling growth of white-fronted geese at several sites on the ACP during 2011 – 2014. Breeding phenology has advanced. Across sites and years, mean clutch size was about 4 eggs and mean nest success 0.62 (range 0.41 – 0.79); we found no evidence for change since the 1980's, but nest success varied by year and site. Peak hatch corresponded closely with peak forage quality at both fresh water and salt-marsh habitat sites. Growth rates of goslings were among the highest previously reported in Arctic geese; mean gosling mass at 32 days ranged from 1340.2 ± 53.0 g to 1707.2 ± 24.5 g. Growth of goslings did not differ between early and late hatched, but was higher in coastal habitats with salt-tolerant sedges as compared to inland freshwater sites. Our results support the hypothesis that reproductive success is likely an important factor driving population increase of white-fronted geese on the ACP. This population remains well below carrying capacity and rapid population growth is likely to continue. At present we found no evidence of phenological mismatch between the timing of gosling hatch and peak forage quality. Climate change may have had a positive influence on gosling growth through increased forage availability.

Comparative Demography of Lesser Snow Geese and Black Brant on the Colville River Delta, Alaska

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Nesting populations of lesser snow geese (*Chen caerulescens caerulescens*) and black brant (*Branta bernicla nigricans*) are increasing on the Arctic Coastal Plain of northern Alaska. Brant and snow geese share nesting and brood-rearing habitats on the Colville River Delta, where we have contrasted population processes between species since 2011. Survival of nests to hatch was higher for snow geese (0.79 – 0.90) than for brant (0.54 – 0.72) in years when grizzly bears (*Ursus arctos*) were not observed on nesting colonies. Bear predation resulted in especially low nest survival for snow geese (0.36) and brant (0.20) in one year. Nest survival of snow geese and brant were similar (0.56) in a year when bears were observed on some snow goose nesting islands, but not on the main brant colony. When bears were absent, avian predators and fox were responsible for most nest loss, especially among brant. Hunter harvest rates for adults of both species were low ($\leq$0.03) and return rates of adult females in their first year after banding were higher for snow geese (0.17) than for brant (0.12). Among females banded as goslings, 6.3% of snow geese were detected on the Colville River Delta at 2-years of age, whereas 1.1% of marked brant were detected as 2-year olds. Estimates of survival and recruitment are pending completion of further mark/recapture effort. However, higher nest survival in three of four years, higher adult return rates, and evidence of nesting at a younger age suggest that snow geese may have a demographic advantage over brant. There is currently no evidence that snow geese have displaced brant from nesting areas, nor that growth rates of juvenile brant are adversely affected by the presence of snow geese on brood rearing habitats. Future colony growth for both species may depend on whether bears acclimate to goose eggs as a food source.

Is apparent nest success a useful metric of nest survival in colonial lesser snow and Ross's geese nesting at high densities?

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Apparent nest success – the fraction of the number of nests sampled (without accounting for undetected loss of nests) that produce at least one offspring – can result in estimates of nest success that are biased high. However, in some situations, unbiased estimates of apparent nest success are possible when nests are detected with high probability by researchers such that destroyed nests are found with the same probability as successful nests. Such situations can occur in colonial species or species with noncryptic nests that are unobstructed by vegetation cover, and when destruction of nests occurs catastrophically, apparent estimates may outperform Mayfield estimates. We investigated nest survival in lesser snow geese (*Chen caerulescens*) and Ross's geese (*Chen rossii*) at Karrak Lake, Nunavut, a large colony in the Central Canadian Arctic that contained over 1 million nesting geese in some years. We first compared annual apparent nest success with Mayfield nest survival estimated in Program MARK. Mayfield estimates for both species combined ranged 0.42-0.87 (mean 0.71) during 1995-2012, and were on average 0.02 less than apparent estimates, with Ross's geese experiencing higher nest survival than lesser snow geese. We were also interested in identifying factors thought to influence nest survival, and included covariates of nest age, annual fat and protein indices, nest initiation date, weather, spring chronology, and observer effects. For both species, nest survival was greatest for early-initiated nests. Best-supported models suggested that nest survival declined with nest age, although confidence limits around estimated of slopes for most years included zero. We suggest that apparent nest success is sufficiently unbiased in such situations as to be a useful measure of nest survival.

Snow goose colony: a risky nesting area for shorebirds

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Indirect interactions among tundra prey species, mediated by shared predators, could potentially influence the distribution and abundance of vulnerable species such as arctic-nesting shorebirds. We investigated trophic interactions between Greater Snow Geese (*Chen caerulescens atlantica*) and American Golden-Plover (*Pluvialis dominica*), two prey species sharing the same nest predators on Bylot Island in the Canadian High Arctic. We hypothesized that geese negatively impact shorebirds by increasing nest predation risk. The American Golden-Plover was used as a target species because it presented higher detection rates compared to other shorebird species. We examined also if the relationship between geese and plovers could be modulated by the cyclic lemming populations, which are known to strongly influence predation pressure on arctic birds. The Arctic fox (*Vulpes lagopus*) is known to be the main nest predator for both shorebirds and geese. The other relatively abundant nest predators on Bylot Island are the Parasitic Jaeger (*Stercorarius parasiticus*), the Glaucous Gull (*Larus hyperboreus*) and the Common Raven (*Corvus corax*). From 2010 to 2014, we quantified the effect of goose abundance, distance to the center of the goose colony and lemming abundance on i) nest predator abundance, ii) American Golden-Plover nesting distribution and iii) shorebird nest predation risk. Predation risk was assessed with the use of artificial nests deployed along transects distributed over a large area of ~280 km^2 and up to 21 km away from the center of the main goose colony. For each transect (n > 146 annually), the abundance of nest predators and nesting American Golden-Plovers was recorded. The boundary of the snow goose colony was determined each year through helicopter survey. We found that nest predator occurrence was positively related to snow goose densities and this relationship was stronger when the density of lemmings was low. Occurrence of nesting plovers was lower in areas with high goose densities and much lower near the goose colony, especially during lemming peaks. Finally, predation pressure on artificial shorebird nests was higher close to the goose colony**.** Overall, our results support the hypothesis that geese negatively affect shorebirds through shared predators. Hence, the recent increases in arctic-nesting goose populations likely lead to decreases in enemy-free space for shorebirds. Further investigations would be required to determine the population level consequences of such short-term and overlooked negative effects of overabundant geese on vulnerable tundra-nesting species.

Parental quality and mate change affects growth and pre-fledging survival of black brant goslings

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Growth and survival during the pre-fledging period are important fitness components for Arctic nesting geese. Given the socially monogamous mating system and bi-parental care of arctic nesting geese including black brant (*Branta bernicla nigricans*) we hypothesized that parental quality (e.g., age) and mate familiarity may influence the quality of early life conditions for goslings. To examine our hypotheses we used longitudinal data from a long-term mark-recapture study of black brant at the Tutakoke River brant colony on the Yukon-Kuskokwim delta in southwestern, AK. From 1990-2014, we applied webtags during hatch to 16,494 goslings belonging to 5,636 broods attended by parents with known mating history. Subsequently, during banding drives conducted during adult remigial molt (25-30 days after peak hatch) we recaptured and weighed 2,507 webtagged goslings. Using generalized linear models (all covariates were z-standardized) we found that gosling growth rates declined with advancing age of the father (β = -16.1 (g); SE = 5.3), but improved with the age of the mother (β = 12.6 (g); SE = 5.1). Additionally, we found that pre-fledging survival, we used recapture rates of webtagged goslings as a proxy to survival, was negatively affected by mate change. Across years, the average recapture rate of webtagged goslings was 18.3% (SE = 1.8%) while recapture rates for goslings attended by pairs apparently breeding together for the first time was 14.2% (SE = 1.4%). These results suggest potential trade-offs between reduced gosling quality with increased age of the male and a reduction (at least in the short-term) in pre-fledging survival with mate change perhaps requiring correct mate retention decisions to optimize lifetime fitness of adult female brant. However, these results are preliminary and future analyses will include random effects of parents.

Effects of mate quality and pair-bond dynamics on rates of survival and breeding in black brant

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Survival and breeding probability are important fitness components for long-lived vertebrates. Given the socially monogamous mating system of Arctic nesting geese including black brant (*Branta bernicla nigricans*) we hypothesized that mate quality (e.g., body mass) and mate change (due to apparent death of previous mate or divorce) may influence the probability that brant survive and breed. To examine these questions we used longitudinal data from a long-term mark-recapture study of black brant at the Tutakoke River brant colony (TRC) on the Yukon-Kuskokwim Delta in southwestern, AK. From 1990-2014, we encountered 3,039 adult females and 3,063 adult males breeding at TRC who had at least one marked mate during their lifetime. We conducted preliminary analyses using the Barker robust design implemented in Program Mark. We found that body mass of an individual's mate during the previous year's brood rearing period positively affected future breeding probability of females ($\beta = 0.55$; SE = 0.24), but not males ($\beta = 0.07$; SE = 0.12). Survival was reduced for females ($\beta = -0.10$; SE = 0.02) and males ($\beta = -0.19$; SE = 0.03) following the initial breeding attempt with a new mate when the previous mate apparently died. Interestingly, individuals who had been divorced from the previous mate seem to not suffer reduced survival. Alternatively, a reduction in breeding probability is experienced by females ($\beta = -0.12$; SE = 0.02) and males ($\beta = -0.17$; SE = 0.03) after divorce from their previous mate. While these results are preliminary they suggest that to fully understand factors affecting vital rates of adult brant, consideration must be given to mate quality and pair-bond dynamics. Future analyses, will explore interactions between individual quality, mate quality, pair-bond dynamics, and fitness components including permanent emigration from TRC.

Plasticity in Speed and Timing of Flight Feather Molt in the Greater Snow Goose, a High-Arctic Nesting Species

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Environmental and temporal constraints are particularly strong in migratory species that breed in the Arctic. In addition to breeding, Anatidae have to renew simultaneously all their flight feathers during the short Arctic summer. We examine how both temporal constraints and climate could affect the phenology of flight feathers molt in the greater snow goose (*Chen caerulescens atlantica*), a high-arctic nesting species. We hypothesized that the timing of molt should be less flexible than the timing of breeding due to the constraint of regaining flight capabilities before the onset of the fall migration. We used a database of 1412 molting adult females measured over 15 years in Bylot Island, Nunavut. Ninth primary length was used to determine the molt stage and feather growth speed. We found a positive relationship between median hatching date and molt initiation date, and the slope did not differ from 1 (1.3, 95% CI: 0.9-1.8). This suggests that, contrary to our initial expectation, the interval between hatching and molt initiation is fixed and geese do not advance the start of molt when the reproductive phenology is late. Nonetheless, there was no relationship between median hatching date and the date at which birds regained flight capacity at the end of molt. This suggests that the date of end of molt is relatively fixed and independent of reproductive phenology. There was a trend for an increase in the speed of flight feather growth in years when hatching date was delayed ($p = 0.07$) and this could be the main mechanism that could explain adjustment in molt phenology in this species. Finally, we found a positive relationship between ninth primary length (corrected for inter-annual variations) and body condition, suggesting a delay in molting for individuals in poor condition. These results suggest that molt plasticity is primarily achieved by variations in feather growth speed in snow geese. This phenotypic plasticity could be necessary to complete flight feather renewal before the end of the short summer in the High Arctic, independently of reproductive phenology and spring environmental conditions. These results are particularly novel because until now molt speed had been found to be rather inflexible in geese.

Ecological implications of reduced forage quality on growth and survival of sympatric geese

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Allometric constraints associated with digesting leaves require relatively small avian herbivores to consume high-quality forage. How such constraints are overcome during ontogeny when energy and nutrient requirements are relatively high has not been adequately explored. We compared growth trajectories of Canada and lesser snow goose goslings raised on grass-based diets that differed in protein (10, 14, or 18%) and fiber (30 or 45%) with those of free-living goslings on Akimiski Island, Canada. This common-garden experiment allowed us to test the hypotheses that (1) smaller-bodied geese are more negatively affected by reduced forage quality than larger-bodied geese, and (2) goslings from subarctic brood-rearing areas have a limited capacity to slow growth in response to reduced forage quality. Canada goose goslings fed low protein (10%) diets were on average 44% lighter in body mass, had slower growth rates, and were delayed >20 days in reaching 90% of asymptotic size compared to Canada goose goslings fed 18% protein. In contrast, snow goose goslings were unable to survive on the low protein diets, and those fed high or medium protein diets grew at a similar rate and achieved similar asymptotic size. Canada and snow goose goslings fed low protein diets had reduced growth rates of the tarsus and delayed emergence of the 9th primary. Free-ranging Canada goslings on Akimiski Island were similar in mass and structural size to captive-reared goslings fed low protein diets. In contrast, snow goslings were similar in mass and structural size to the captive-reared goslings fed the high and medium protein diets. This suggests that degraded habitats with mostly low protein forage may be able to support Canada goslings better than snow goslings which require higher quality forage to survive. Size-related differences in gosling growth and survival in response to diminished diet quality may influence population size when available food reaches a lower threshold in protein content. However, goslings can avoid such density-dependent population regulation if they are able to move their broods and find adequate quality and quantity of forage.

Assessing Competition by Cackling Geese and Lesser Snow Geese on Breeding Atlantic Brant

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The most recent mid-winter surveys suggest Atlantic brant (*Branta bernicla hrota*) populations are suffering their lowest numbers in over 30 years. While brant populations are known to fluctuate, productivity surveys on the wintering grounds indicate the number of young in flocks has declined in recent decades. This may be indicative of a limitation on the breeding grounds. Expanding populations of lesser snow geese (*Chen caerulescens caerulescens*) and cackling geese (*Branta hutchinsii*), utilizing the same breeding grounds, may be contributing to the decline in brant breeding success. Identifying all forms of interspecific competition among brant and these other arctic nesting goose species is key to understanding any possible limitations that may be occurring. Southampton Island has historically supported a breeding population of Atlantic brant; however, the number of breeding brant on the island decreased significantly in the last 30 years. The island also supports populations of nesting lesser snow geese and cackling geese. We studied the interactions occurring between brant, snow geese, and cackling geese on the coast of East Bay, Southampton Island in the summer of 2014. We compared historical brant nesting sites to those found in 2014 to assess potential pre-emptive competition occurring between brant and cackling geese. Increased presence of cackling goose nesting in areas previously occupied by brant has limited brant to nesting in small and less than optimal pockets. Exclusion from optimal nesting islands can lead to increased depredation by predators. In addition to this exclusion, increased populations of nesting snow geese and cackling geese at East Bay may be drawing higher densities of predators than a nesting area occupied predominantly by brant. Out of a total of 44 brant nests found, 42 failed, and we quantified the nest accessibility to arctic foxes to determine nest fate probabilities based on a number of covariates (i.e. island size, distance to mainland body, water depth along shallowest route, etc.). As Atlantic brant populations have experienced long-term fluctuations, efforts to understand their limitations have focused on the wintering grounds. However, as lesser snow geese and cackling geese populations continue to grow and exert potentially direct or indirect competitive pressure on the brant breeding grounds, it is critical for future management to quantify the presence and strength of such a possible limitation.

Temporal trends and spatial variation in components of reproductive success of Greater Snow Geese on Bylot Island.

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The timing of breeding is a critical component of reproductive success in arctic-nesting geese. In Greater Snow Geese (*Chen caerulescens atlantica*), it has been shown that females laying earlier than the population mean achieve the highest reproductive success. However, in the last decades conditions on their breeding ground have changed due to climate warming, leading to an increasing primary production of vascular plants and an earlier date of snow-melt. This creates a high potential for an increased trophic mismatch between hatching date of goslings and the date of peak nutritive quality in their food plants over time. This mismatch could lead to an increase in the differences between the laying date yielding the highest reproductive success and the mean laying date of the population. However, spatial variability in reproductive success within the colony has the potential to mask long-term trends in its components. To address this problem, we analyzed temporal trends and spatial variation in four components of reproductive success of the Bylot Island colony: Laying date, hatching date, clutch size as well as nesting success over the last 26 years. Our main hypothesis was that annual variation in these different components of reproductive success was consistent across different areas of the breeding colony. To examine these questions, we used three datasets of nests that were monitored (1) in the core area of the colony, (2) in random plots throughout the colony and (3) at a site where geese nest at low density, about 20 km from the edge of the main colony. Maximum sample size in each group was 1946, 927 and 716 nests respectively. Preliminary analyses suggest laying date has not advanced. There is some spatial variation in the laying date, but these differences were not consistent among years. Geese nesting away from the colony tended to lay on average 1 day earlier than in the core of the colony. Moreover, the effect of years and the interaction between years and locations on laying date and hatching date was highly significant. We are currently examining environmental conditions that could explain these differences. Accounting for these variations in our dataset will be important when looking for long-term trends in various components of reproductive success. Future work will include investigation into how environmental conditions at migratory stopovers affect the timing of migration and may pose a constraint to laying date.

Latent effects of initial maternal investment and quality on pre-fledging survival in black brant

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The black brant (*Branta bernicla nigricans*) is a small, arctic nesting goose, occurring in coastal estuaries and wetlands along the Pacific coast. Brant populations on the Yukon-Kuskokwim Delta have declined substantially since the 1980's, and the population remains significantly below historic levels. To better understand the effects of initial investment in clutches by adult females on future brood survival, we analyzed apparent brood survival data collected at the Tutakoke River Brant Colony from 1994-2013. Egg volume had a positive effect on gosling apparent survival rates, while apparent survival declined across the laying sequence, and with female age. These findings indicate effects of reproductive investment on pre-fledging survival, as well as potentially diminishing fitness returns of increasing clutch sizes.

Population reduction efforts and spring nutrition in midcontinent lesser snow geese

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Previous research suggested that foraging by an increasing midcontinent population of snow geese was sufficiently intense to imperil arctic ecosystems. Consequently, a spring conservation harvest was implemented in 1999 with the primary goal of reducing the abundance of these birds by decreasing adult survival probability. A secondary benefit of increased harvest during spring migration could be a reduced ability of geese to acquire nutrients for reproduction, leading to a further decline in the population growth rate. We tested the hypothesis that spring harvest has impeded nutrient storage on the Canadian prairies, an important spring staging area for midcontinent lesser snow geese (*Chen caerulescens caerulescens*). We sampled adult and subadult lesser snow geese staging in southern Manitoba in years before the spring conservation harvest (1983, 1984, 1988-1993), and during the conservation harvest (2002-2007). We estimated mean body mass, total body fat and lean dry mass standardized to two sampling dates each year (13 April and 2 May), and compared body composition between the two periods. Models that included spring harvest ranked poorly among *a priori* candidate sets using an AIC framework. Contrary to our predictions, snow geese were in equal or better nutritional condition after spring harvests began than they were before. After spring harvests began in 1999, geese maintained or increased daily rates of nutrient deposition relative to body size during the staging period. Our results show that disturbance from spring harvesting by hunters did not reduce spring nutrient storage on prairie staging areas. Nonetheless, a long-term decline in the production of young is evident for this population, and is likely an outcome of density dependence. Density dependence may influence the ability of midcontinent snow geese to complete nutrient storage north of the prairies, as they converge toward arctic nesting colonies.

Integrating experiences from North America to attain the wise use of geese populations in Western Siberia

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In Russia, there are no mechanisms to monitor goose populations, no adequate hunting regulation and no effective protection of rare species or of key sites. In the absence of such basic necessities, it is difficult to implement evidence-based scientific approaches to goose resource management. In contemporary Russia, the most effective means of implementing conservation measures is through the creation of hunting free zones. Justifying the creation of such zones requires knowledge of the abundance and trends goose populations and the key areas they exploit. We chose to create such a model scheme in the Yamalo-Nenets Autonomous Okrug of Western Siberia. Based on North American experiences, we used ultra-light aircraft to count waterfowl and applied GSM-GPS transmitters to determine geese migration patterns and highlight the key sites they exploit. In springs and autumns of 2012-2014, we conducted more than 50 000 km of aerial survey transect flights to count 24 species of waterfowl including six goose species, confirming numbers by photography. We estimated population abundance for each species, accounting for differential densities in 16 selected habitat types, classified from Landsat imagery. By extrapolation, we determined the total number of counted birds for each species in each selected habitat type, calculated the mean density within each habitat type in the survey area and from this determined the estimated number in the entire study area. We obtained new data relating to migration pattern and key areas, breeding success, spatial distribution and limiting factors. Using anonymous questionnaires, we were able to make preliminary assessments of the size of the hunting bag and the extent of illegal shooting. The results of our counts indicated declines in many hunted species. Based on these data, we recommended the creation of 10 hunting free zones at key sites, including boundary definitions and recommendations for amendments to the existing hunting regulations. GIS layers were compiled to show the routes of aerial surveys, the key sites boundaries, the main migration routes, the distribution of bird detections on transect and the locations of the rare species. These techniques offer a vital basis for longer term continued monitoring and development of a system to support the wise use of goose populations in the region and can be used in other regions of Russia.

Taxonomic status and comparative phylogeography of Cackling Geese and Canada Geese

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Natural geological and evolutionary processes primarily associated with climatic events have led to vicariance and long-term isolation that have left indelible signatures in the spatial distribution of genetic variation for many species inhabiting high latitudes, including arctic-nesting geese. For two species of white-cheeked geese (*Branta canadensis* and *B. hutchinsii*), geographically expansive genetic data (N > 1600 samples) collected from locales (N > 50) covering the entire species' distribution for both species support current taxonomic status. We used next generation sequencing (NGS) to sequence and assemble complete mitochondria genomes (ca. 16,747 bp) from individuals representing each of the subspecies of Cackling and Canada geese. We observed >240 diagnostic base pair differences between individuals from both species representing a ~1.5% difference between the species mitogenomes. Coalescence and Approximate Bayesian Computation (ABC) analyses of nuclear microsatellite loci and control region mitochondrial DNA sequences revealed considerable phylogeographic structure. Spatial patterns are generally consistent with an isolation-by-distance relationship but are not entirely consistent with recognized subspecies or managed population boundaries, reflecting the locations of refugia and post-glacial range expansion. Spatial genetic structure in southern temperate areas is also evident but interpretation of patterns is confounded by geographically expansive reintroduction programs.

Predicted eelgrass response to sea level rise and its availability to foraging Black Brant in Pacific coast estuaries

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Managers need to predict how animals will respond to habitat redistributions caused by climate change. Our objective was to model the effects of sea level rise on total eelgrass (Zostera marina) habitat area and on the amount of that area that is accessible to brant geese (Branta bernicla), specialist grazers of eelgrass. Digital elevation models were developed for seven estuaries from Alaska, Washington, California (USA), and Mexico. Scenarios of future total eelgrass area were derived from combinations of estuarine specific sediment and tectonic rates (i.e., bottom change rate) with three rates of eustatic sea level rise (ESLR). Percentages of total eelgrass areas that were accessible to foraging brant were determined for December when the birds overwinter at more southerly sites and in April as they move north to sites where they build body stores on their way to nesting areas in Alaska. The modeling showed that accessible eelgrass area could be lower than total area due to how daytime low-tide height, eelgrass shoot length, and the upper elevation of eelgrass determined brant-reaching depth. Projections of future eelgrass area indicated that present-day ESLR (2.8 mm/yr) and bottom change rates should sustain the current pattern of estuarine use by brant except in Morro Bay, where use should decrease because eelgrass is being ejected from this estuary by a positive bottom change rate. Higher ESLR rates (6.3 and 12.7 mm/yr) should result in less brant use of estuaries at the northern and southern ends of the flyway, particularly during the winter, but more use of mid-latitude estuaries. The capacity of mid-latitude estuaries to function as brant feeding refugia, or for these estuaries and Izembek Lagoon to provide drift rather than attached leaves, is eventually limited by the decrease in total eelgrass area, which is a result of a light extinction effect on the eelgrass, or the habitat being pushed out of the estuary by positive tectonic rates. Management responses are limited to the increase or decrease of sediment supply and the relocation of levees to allow for upslope migration of eelgrass habitat.

Indirect Effects of Geese on Arctic-breeding Shorebirds: What Do We Know?

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Shorebirds are the most diverse and abundant group of birds in many arctic locations. More than 60% of shorebird populations breeding in Arctic Canada are believed to be declining relative to 1970s levels. This proportion of declining species is higher than for shorebirds breeding elsewhere in North America or elsewhere around the globe. There are many possible factors contributing to this disproportionate number of declines, including habitat damage by arctic geese at shorebirds' breeding and staging sites. We review the extent of spatial overlap between shorebirds and geese to demonstrate the potential for interactions that have population-level consequences for shorebirds. We present results from our ongoing studies of breeding shorebirds (2000-2014) at a site near to a breeding colony of Lesser Snow Geese (*Chen caerulescens caerulescens*) on Southampton Island and from a site with new/intermittent goose breeding at Coats Island, Nunavut. At Southampton Island, nest survival for several shorebird species is below that required for maintenance of stable populations while nest survival is higher at the less impacted Coats Island site. Shorebirds' reproductive success varies widely across years and is closely related to the abundance or activity of nest predators, primarily arctic foxes (*Vulpes lagopus*). These predators, potentially drawn to areas with breeding geese, are believed to be an important mechanism whereby geese might indirectly affect shorebirds' reproductive success. Habitat degradation is another potential mechanism but the effects are less clear. Some shorebird species select concealed nest sites while others do not. Extreme habitat degradation might lead to avoidance of areas by shorebirds requiring concealed nest sites, but to date we found little evidence of a relationship between shorebirds' nest habitat and nest survival. The current evidence for large-scale effects of overabundant geese on Arctic-breeding shorebirds is therefore mixed, with several important components of the story still lacking. Studies now in progress should address several of these important gaps in the coming years.

The Importance of Pre-nesting Spring Staging Areas on the Interior Yukon-Kuskokwim Delta for Populations of Geese, Swan and Crane

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Coastal nesting areas of the Yukon-Kuskokwim Delta have understandably received important recognition for their importance to populations of cackling goose, Pacific greater-white-fronted geese, emperor geese, black brant, tundra swan, and sandhill crane. However, several independent tracking studies have shown extended use of interior spring staging areas of the Yukon-Kuskokwim Delta that have been previously unrecognized in importance or significance. Furthermore, much of the use quantified by these tracking studies indicates a high proportion of this pre-nesting period use occurs out of the boundaries of the Yukon Delta National Wildlife Refuge. Information available from spring subsistence harvest also indicates high levels of reliance upon these same populations for subsistence use. Available information is synthesized to identify spatial occurrence and temporal timing of these regions to provide managers insights to an often overlooked period of importance to goose populations of significance in this region.

Variation in Winter Location and Spring Migration Phenology of Black Brant: Implications for Timing of Arrival and Nesting of sub-Arctic and Arctic Breeders

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The winter distribution of the eastern Pacific Flyway of Black Brant has shifted northward out of Mexico to Alaska presumably in response to climate warming. A more northern wintering area may provide fitness advantages from a reduction in migration distance, greater access to high quality food resources closer to the breeding grounds, and an ability to nest earlier. We equipped adult female brant with archival light-recording devices (geolocators) to examine variation in winter location and timing of spring migration and nesting between colonies on the Yukon-Kuskokwim Delta (YKD) in southwestern Alaska and the Colville River Delta (CRD) in the central Arctic coast of Alaska. We also analyzed long-term first arrival observations on the CRD to determine whether brant have advanced their migration phenology and whether they are keeping pace with rates in advancement in warming between 1969 and 2013. While nearly all (>90%) of the females recovered with geolocators on YKD (n = 46) wintered in Mexico, only half of the marked females recovered on the CRD (n = 47) wintered there. Those birds that wintered in Alaska tended to initiate spring migration, arrive on the breeding grounds and nest earlier than those that wintered in Mexico. Nest success did not vary between wintering location. Over the 45-year period, we detected a significant annual rate of advancement in first arrival (0.14 days/year: 90%CI: 0.08-0.21) for brant nesting on the CRD. However, the mean rate of advancement of first arrival was 0.84 (90%CI: 0.36-1.33) that of the rate of annual increase in mean May temperature suggesting that Black Brant may not be keeping pace with climate warming on the CRD. Rates of advancement for Black Brant on the CRD appear to be constrained by events off the breeding grounds and mostly likely at Izembek Lagoon.

Breeding and non-breeding birds do not differ in their proportion of time feeding or expenditure during spring migration

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Among iteroparous, monogamous species, breeding requires extensive energetic investment from the female and male. Theory predicts that breeding individuals would 'prepare' for the breeding event by feeding more and expending less energy than non-breeding individuals. We tested this assumption by fitting hybrid Global Positioning System (GPS)-acceleration (ACC) tracking devices on male Greenland White-fronted Geese (*Anser albifrons flavirostris*) and compared the proportion of time feeding and energy expenditure during spring migration and the breeding period among two breeding and 13 non-breeding individuals. We found no significant differences in the proportion of time feeding or overall dynamic body acceleration (a proxy for energy expenditure) between breeding and non-breeding males during spring migration. During the breeding period, breeding males fed significantly less, but also expended significantly less energy. These findings suggest (i) all birds 'planned' on breeding and prepared similarly and/or (ii) birds made breeding decisions based on factors encountered on breeding areas (e.g., environmental conditions). These results highlight the capabilities of GPS-ACC tracking devices, such as to support retrospective behavioural analyses of birds subsequently observed on wintering areas without young (considered non-breeding birds) to determine the cause (i.e., deferral or nest failure) of low breeding success. Consequently, these analyses provide unprecedented insight into the fitness consequences of individual decision-making throughout the year, which we consider to be a major advancement for species that are not observable for periods of the annual cycle (such as Arctic-nesting birds like Greenland White-fronted Geese).

Integrated population modelling reveals a perceived source to be a cryptic sink

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Relationships between fragmented populations are commonly studied as source-sink dynamics, where sources exhibit greater emigration than immigration and/or more births than deaths and sinks the opposing dynamics (immigration exceeds emigration and/or deaths exceed births). Thus, persistence of sinks relies on import of individuals from sources and population management often presumes that large populations are typically sources. Here, we tested this assumption by examining the dynamics of the Greenland White-fronted Goose (*Anser albifrons flavirostris*) population as a case study and the main wintering site (i.e. Wexford, Ireland) as the primary subpopulation. We formed Bayesian integrated population models which combined capture-mark-recapture, population size and recruitment (the proportion of juveniles) data to estimate age-, site-, and year-specific survival, movement and recruitment probabilities over a 27-year period. Survival rates of juveniles (posterior mean 0.70, 95% credible interval 0.43-0.86) and adults at Wexford (0.81, 0.67-0.91) and elsewhere (0.79, 0.34-0.98) remained relatively stable over the study period, as did emigration rates (i.e., there was no temporal trend within age classes), which were greater among birds aged 1 (0.16, 0.01-0.46) than those aged 2+ (0.09, 0.01-0.30). Recruitment rate declined over the study period, varying between 0.44 in 1985 and 0.06 in 1999. The observed persistence of this population was only possible with high rates of immigration, which exceeded emigration in each year. Despite its apparent stability, Wexford has functioned as a sink over the entire study period. These results demonstrate that even large populations can be sinks, and that robust understanding of population dynamics is essential to inform the development of site-safeguard networks. To fully understand persistence of this population, marking efforts at other sites are needed to identify the source(s) 'feeding' Wexford with immigrants.

Abstracts - Posters

Contributed Posters

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(denotes student posters)*

1. Post-hatch movements of sub-arctic Canada geese (*Branta canadensis interior*)

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Geese employ variable strategies of space use during the brooding period to meet their energetic needs including a fixed strategy where broods remain in close proximity to nesting areas and forage on local food resources, and a mobile strategy where broods move away from nesting areas in search of higher quality resources. Canada geese (*Branta canadensis*) occupy a large range of habitats across their range and brood movement strategies may vary as a result. Our goal was to determine what strategy subarctic nesting Canada geese employ at Akimiski Island, Nunavut and Burntpoint Creek, Ontario and what factors influence these movements. It appears that these subarctic nesting Interior Canada geese employ a fixed space brood rearing strategy as most pairs with families of 6-7 week old goslings were found within a short distance of their nest. Annual mean distances moved ranged from 1 – 2.8 km on Akimiski Island and similarly, 1.4 – 2.8 km at Burntpoint Creek, despite major differences in habitat structure and quality. Using Akaike Information Criteria with small-sample correction (AIC_C), we found that variation in distance moved was most influenced by gosling body size and breeding population size. Goslings that moved greater distances were larger in size and originated from nesting areas with fewer breeding pairs. Goslings were in better body condition at Burntpoint Creek (body size Wald Chi-Square = 317.82, $P < 0.001$, $n = 650$). Canada goose gosling body size and condition on Akimiski Island is affected by relatively poor quality intertidal and supratidal graminoid turf brood habitat; its poor condition is due largely to cumulative deterioration primarily attributed to snow goose foraging. Burntpoint Creek brood habitat is a mix of intertidal and supradtidal graminoid turf communities and freshwater graminoid fen with the latter predominating. Habitat condition is not affected by snow geese and overall density of broods is lower at Burntpoint Creek than on Akimiski Island.

2. A metanalysis of band reporting probabilities from waterfowl harvested in North America, 1944-2011

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We assembled published estimates from 13 papers of $\hat{p}$, the probability that hunters report their harvested waterfowl marked with metal leg bands, to the Bird Banding Laboratory (BBL). This literature survey yielded 451 estimates of $\hat{p}$, of which 340 were for ducks and 111 were for geese. We also determined whether estimates were adjusted for so-called solicitation, i.e., reported bands were assumed to be unsolicited if submitted to the BBL by the hunter that harvested the banded bird, whereas solicited bands were assumed if they were reported by state or federal agency personnel on behalf of the hunter. I further categorized estimates according to study design (hunter questionnaire vs. reward band). I compiled the taxonomic levels (Order, Subfamily, Genus, Species) and geographic scale such as continental, i.e., U.S. and Canada pooled, Country, Flyway, Harvest region (e.g., as reported by Zimmerman et al. (2009)), or state. We modeled temporal variation in $\hat{p}$ from 1944 to 2011 by considering (i) time series up to cubic polynomial trend, (ii) years grouped by decade, or (iii) grouped by decade, but off offset by 5 years from the first decadal grouping. We used general linear models (GLM) for exploring variation in $\hat{p}$, at different spatial and temporal scales, and chose the best model using an information-theoretic approach. The best model had weight of 0.42, R^2 = 0.86, and included orthogonal effects of solicitation, offset decadal variation (i.e., 1956-1965 vs 1951-1960), geographic region (i.e., flyway or country) and study design (questionnaire vs. reward band). Estimates of $\hat{p}$ did not vary between ducks and geese. However, solicitation increased $\hat{p}$ by 0.037±0.023 (95%CL), and questionnaire-based studies overestimated $\hat{p}$ by 0.054±0.049 compared to reward band studies. During the most recent time group considered, 2006-2011, band reporting rates for birds harvested in Canada were 0.632±0.024, compared to those harvested in the Atlantic Flyway (0.680±0.024), Mississippi Flyway (0.637±0.057), Central Flyway (0.716±0.027), and Pacific Flyway (0.723±0.031). In place of existing published estimates, available only as a broken time series over the last 6 decades and derived with a mix of study designs and different scopes of inference, a comprehensive taxonomic, spatial, temporal and design-based model of all recoveries to date (perhaps including all gamebirds marked in North America) is encouraged. This may improve retrospective analyses of gamebird population dynamics, and lead to a better understanding of the ecological factors behind such dynamics.

3. Demographics of stable or declining Lesser Snow Goose colonies

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The Lesser Snow Goose colonies on Akimiski Island (AKI) and at Cape Henrietta Maria (CHM) are distinct among the mid-continent population as they are the most southerly snow goose colonies in North America. They also appear to be relatively stable (AKI) or are possibly in decline (CHM). We have been banding geese annually at AKI since 1998 and are able to incorporate band return and recapture data into demographic models. At CHM we banded geese from 2000 to 2007 and are able to use dead recovery models to estimate demographic rates for those birds. For both colonies we conducted aerial surveys to monitor the abundance of breeding birds and have monitored productivity at banding. Using multi-state models to estimate demographic parameters for birds banded as goslings at AKI, we estimated the correlation between harvest and non-harvest mortality and found no significant correlation for either adults or juveniles indicating that harvest is likely completely additive. However, there was surprisingly higher non-harvest mortality rates estimated for adult geese than expected which may be attributed to unreported aboriginal harvest. Since estimated harvest mortality rates are higher for these colonies than those reported for other mid-continent colonies, we compared the timing and location of harvest as a potential cause. By starting southward migration from breeding areas closer to prairie staging areas, birds from southern colonies may be exposed to higher and earlier harvest mortality than birds from more northerly colonies. However, cumulative harvest rates do not suggest that September harvest is any higher for birds from AKI or CHM than for any other harvest month. September harvest adds a relatively small proportion to the total annual harvest for southern colonies but does not make up the difference observed. Productivity metrics measured at banding suggested a potential increasing trend in productivity at both colonies possibly due to improved spring conditions. However, AKI first year non-harvest mortality was estimated >50% which may speak to the limitations of the brood rearing range suggesting high mortality due to malnutrition either pre or post fledging. A similar situation may occur at CHM where range is also in poor condition. We found that higher adult mortality possibly due to unreported harvest and poor gosling survival due to poor brood rearing range conditions are contributing factors to holding Lesser Snow Goose abundance on Akimiski Island and at Cape Henrietta Maria at the levels observed.

4. Rapid Growth of a Lesser Snow Goose Colony on the Ikpikpuk River Delta, North Slope, Alaska

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The Mid-Continent Population (MCP) of lesser snow geese (*Chen c. caerulescens*) (hereafter snow geese) have caused severe ecological damage to breeding areas and are considered overabundant. The Western Arctic Population (WAP) of snow geese also has grown substantially over the past ~30 years and currently exceeds population management objectives. Given management concerns regarding overabundant snow goose populations throughout North America, we have monitored changes in population size of the largest snow goose colony on the Alaskan coastal plain on the Ikpikpuk River delta, Alaska, since 1992. We flew aerial surveys annually 1992–2013 to enumerate nesting snow geese in mid-June. We conducted ground searches 1–2 weeks post hatch in 1992, 1993, and 2001–2013 to estimate nesting success. Brood-rearing group size, distribution, and composition were estimated by aerial surveys conducted one month post hatch. The colony increased from ~60 nests in 1992 to 335 nests by 2001 and continued to increase rapidly to over 9,000 nests by 2013. The number of flying birds, assumed to be non- and failed-breeding adults, increased concurrently from 80 to 2,500 birds. Between 2001 and 2008. nest success averaged 79% (range 48–97%), but decreased to 1% and 8% in 2009 and 2010, respectively. Since 2010, nest success was moderate (range 42–66%). The number of brood rearing/molting birds varied annually and ranged from ~215 to over 21,000 snow geese in the survey area. The number of goslings in molting groups ranged from ~70 in 1996 to nearly 10,000 in 2011. Immigration of nesting birds and high nesting success both probably have contributed to the growth of this colony, although in recent years, brown bear (*Ursus arctos*) and other predators have reduced the colony growth rate through nest depredation. Substantial nest destruction by bears occurred at the Ikpikpuk colony during 4 of 5 most current years (2009–2013). It is notable that the colony, now with nearly 10,000 nesting pairs, appears able to sustain multiple seasons of fairly severe predation, managing in the last 3 years to hatch relatively large numbers of eggs despite the presence of bears. This is in contrast to earlier years at the Ikpikpuk and at other smaller snow goose colonies on the North Slope, where the appearance of mammalian predators in the colony typically resulted in near complete failure, often on an annual basis.

5. Increases in Exposed Peat from 1992 to 2010 in association with increased light goose populations in the Queen Maud Gulf Bird Migratory Sanctuary

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Intensive foraging by high densities of Ross's and Snow Geese has caused extensive alteration to various arctic habitats on the mainland south of Queen Maud Gulf. Major habitats of (i) wet sedge meadows, (ii) drier lowland tundra, and (iii) upland heath tundra have been altered to exposed peat habitat denuded of vegetation. Existing digital satellite imagery (Landsat) of the entire Queen Maud Gulf Migratory Bird Sanctuary (QMGMBS, ~63,000 km^2) from 1986 to 1992 had been analyzed, enhanced and classified by Didiuk and Ferguson (2005); they estimated that exposed peat habitat covered 276 km^2 of the 51,226 km^2 of nonaquatic habitat by 1992. Populations of Snow and Ross's Geese there have continued to increase exponentially in abundance and densities from that time to 2011, particularly in the eastern portion of QMGMBS. We estimated the distribution and extent of exposed peat over this 36,374 km^2 eastern portion composed of 26,685 km^2 of nonaquatic habitat using Landsat imagery from 2010 and 2011. We used supervised classification methods based on training areas developed from the classification by Didiuk and Ferguson (2005) to identify and digitally map exposed peat and other habitats in our overlapping study areas. Our classification estimated that exposed peat habitat increased by 411% since 1992, covering an area of 1373 km^2 by 2011. Expansion of exposed peat habitat corresponded strongly with contemporaneous boundaries of the largest Snow and Ross's goose colonies known in the region. A net increase in exposed peat also occurred outside of goose colony boundaries from 1986-1992 to 2010-2011; while possible classification error or variation in moisture conditions between years may have accounted for a portion of this, foraging by nonbreeding geese during the summer, or by geese that had dispersed from nesting colonies with their young after hatch undoubtedly contributed to this increase. Detailed ground studies with herbivore exclosures are currently underway in this region to estimate (i) annual removal of vegetation by local herbivores, (ii) carrying capacity of the northern portion of QMGMBS for geese and (iii) the potential for recovery of habitats in the absence of herbivores.

6. Survival and Fidelity of Atlantic Brant Banded on Southampton Island and Baffin Island, Nunavut, 2000-2011

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Abundance of the North American Atlantic brant (*Branta bernicla hrota*) population is monitored principally through annual mid-winter surveys conducted in the Atlantic Flyway. Abundance estimates fluctuate widely among years, but processes underlying this variability are poorly understood, in part due to a lack of information on demographic parameters, survival rates in particular. We analysed banding, recapture, and recovery data derived from >14,000 Atlantic brant marked and released on Southampton Island and Baffin Island, Nunavut, during the period 2000-2011. Objectives of our analysis were to (1) provide baseline, contemporary survival rate estimates for juvenile and adult brant, (2) explore patterns of spatial and temporal variation in survival, and (3) evaluate potential changes (trends) in survival over time. Use of combined recapture-recovery models to estimate survival further allowed us to quantify rates of fidelity to the sampled areas, in this case, molting areas on Baffin and Southampton. For our primary analysis, we focused on adult (after-hatch-year) brant and used data from both banding locations to estimate population parameters. A secondary analysis involving brant marked on Baffin Island only was conducted to estimate juvenile (hatch-year) survival. Candidate models variously included additive and interactive effects of year, origin (i.e., banding location), and age on both survival and fidelity. For adults, the best supported model allowed survival rates to vary among years but assumed no differences in survival with respect to banding origin. Adult annual survival rate estimates ranged from 0.753 (± 0.018 SE) to 0.901 (± 0.017 SE) and averaged 0.837 (± 0.049 SE) over all years. In general, there was little indication of a trend in survival rate estimates over time, and models explicitly incorporating linear and quadratic time trends in survival were poorly supported by the data. Fidelity of adults to molting areas varied among years but generally exceeded 0.80. Juvenile survival was best modeled as varying over time in a manner parallel to annual variation in adult survival. That is, years of high adult survival tended to be years of high juvenile survival and vice versa. Juvenile survival rate estimates ranged from 0.318 (± 0.052 SE) to 0.657 (± 0.064 SE) and averaged 0.435 (± 0.097 SE). Our results indicate that Atlantic brant survival rates are dynamic but have shown little to no consistent trend in recent years. Future work will seek to identify sources of variation in annual survival via covariate modeling involving harvest management and environmental factors.

7. Lesser Snow Geese in Wapusk National Park: a hyperabundant problem?

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Wapusk National Park (WNP), located in the Hudson-James Lowlands, on the western shores of Hudson Bay, lies in the transition zone between arctic tundra and taiga. Predating park establishment, the Hudson Bay Project has been studying lesser snow geese (*Chen caerulescens caerulescens*) at La Pérouse Bay since 1968. Snow goose numbers in the park have increased from 2,500 nesting pairs in the 1960s, to over 75,000 nesting pairs today. WNP lies within the migratory route of the mid-continent population of snow geese, so in addition to its resident population, serves as a stopover site for millions of migrating birds as they head for their summering grounds further north.

The large number of resident, and larger number of transient geese, are significantly impacting the ecosystem in WNP. In some areas, intense foraging has resulted in habitat degradation and complete de-vegetation. This is impacting WNP on a larger ecosystem scale, affecting species at multiple trophic levels. Areas are left barren, and in some locations, have been recolonized by new, often inedible, plant species. The goose impacted habitat in WNP is increasing not just through increased goose abundance but through habitat shifts driven by geese seeking new and previously undisturbed areas of the park for nesting and staging.

Park managers are seeking effective ways to manage the abundance and impact of both resident and transient snow geese to minimize or halt destruction of the habitat of WNP. We want to communicate the message of destructive snow goose foraging and its impacts on critical habitat and other species to decision makers, researchers and educators. We want to find new approaches or learn about methods or successes from elsewhere that can be incorporated into monitoring and management in WNP. Maintaining the ecological integrity of WNP is a strategic goal set out in the management plan, and to achieve this requires strong communication, and the sharing of knowledge between managers, researchers, visitors, hunters, trappers, and local and Aboriginal people.

8. Comparisons of Hunting Season and Light Goose Conservation Order Participation and Harvest in the Central and Mississippi Flyways, 1999-2014.

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The mid-continent populations of lesser snow geese (*Chen caerulescens cearulescens*) and Ross's geese (*C. rossii*) (hereinafter, light geese) have increased over the last thirty years. Damage to arctic and sub-arctic habitats by light geese initiated efforts to reduce population levels through regulations changes (e.g., daily bag limit) during regular hunting seasons and implementation of a light goose conservation order (LGCO) in the Central and Mississippi Flyways in 1999. Changes in participation and/or harvest may be one factor contributing to the apparently unsuccessful efforts to reduce light goose populations. We examined current participation and harvest trends in the regular hunting season and LGCO since 1999. We used U.S. Fish and Wildlife Service estimates derived from the Harvest Information Program of goose hunters and harvest in the regular hunting season. For LGCO participants, we used estimates provided by state wildlife agencies derived from surveys of potential participants and their harvest. Approximately 550,000 goose hunters and over 75,000 individuals participated in the regular hunting season and LGCO, respectively, in 1999, and over 1.4 million light geese were harvested in the two flyways. Since 1999, participation during the regular season and the LGCO steadily declined. During the regular season, participation and harvest have declined approximately 37% and 62%, respectively. However, during the LGCO, while participation declined 43%, harvest has steadily increased (31%). Harvest/active goose hunter decreased by 40% during the regular season, but increased by more than 60% during the LGCO. Decreases in participation in the regular season and LGCO may be related to overall declines in waterfowl hunters and reduced interest in harvesting light goose. The increase of harvest during LGCO despite declines in participation likely is the result of hunter proficiency in harvesting light geese or changes in light goose behavior or migration patterns. Harvest estimates from the regular season and LGCO take may not accurately represent actual harvest. Increasing participation and harvest proficiency and implementation of new techniques or methods may help in reducing light geese populations. Participation and harvest monitoring programs should be evaluated or standardized to improve estimates and assist in determining if population reduction goals are being met.

9. Annual Survival of Lesser Snow Geese Marked on the Ikpikpuk River Colony, North Slope, Alaska

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Understanding survival and recovery rates in waterfowl populations is essential to develop and evaluate management strategies. These estimates are particularly important for lesser snow geese (*Chen c. caerulescens*) (hereafter LSGO) because the Mid-Continent Population (MCP) is considered to be overabundant and the Western Arctic Population (WAP) exceeds population management objectives and has recently been designated as overabundant by the Canadian Wildlife Service. We estimated demographic rates by banding LSGO from the Ikpikpuk River colony on the Arctic Coastal Plain of Alaska between 2000 and 2013. The number of nests on the Ikpikpuk River colony increased from ~60 nests in 1992 to over 9,000 nests by 2013. Our objectives were to better understand the growth of this colony, to determine the wintering distribution of individuals marked on the colony, to compare annual survival and recovery rates, and to calculate rates of permanent emigration. We banded 13,690 LSGO between 2000 and 2013 of which we recaptured 1,618 between 2001 and 2013 while 1,630 bands were reported shot or found dead. Models were constructed using program MARK and we used the model constructed by Burnham to estimate probabilities of survival (S), reporting (r), live recapture (p), and capture location fidelity (F). Our top model allowed survival and recapture probability to vary as a function of age, sex, and year, and co-varied by age and sex. Fidelity varied as a function of age, sex, and year, and co-varied between age and year and age and sex. Male and female juvenile survival averaged ~0.95 and adult male and female survival averaged 0.85 and 0.89, respectively. Fidelity to the Ikpikpuk colony was highest for adult females (0.9) and males (0.8) and lowest for juvenile males and females, 0.06 and 0.5, respectively. Band recoveries were reported from the Pacific Flyway, Prairie Canada Region, and the Central and Mississippi Flyways. We captured previously banded birds originating from western Hudson Bay, Queen Maud Gulf, Wrangel Island, and other North Slope banding locations. Adult survival estimates are similar to those reported from the WAP and MCP. Our juvenile survival estimates are higher than most other reported estimates. It is likely this population will continue its growth trajectory unless nest predation and or increased harvest on this population occur.

10. Tule Geese in the Muddy Lakes: helping track molting geese in a remote region of the Yukon Delta NWR

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Cooperative efforts to track movements of Tule Greater White-fronted Goose have occurred within California, Oregon and Alaska for decades. In the early-2000's, after declining numbers of detected Tule Geese at traditional molting areas, a remote region of the Yukon Delta National Wildlife Refuge was searched by aircraft resulting in the discovery of several flocks in the Muddy Lakes region. Aerial telemetry surveys have continued to locate marked individuals in this same region. This unique region of the Yukon-Kuskokwim Delta region is described and telemetry survey data are summarized to provide managers with a glimpse into this important remote region of the Yukon Delta NWR.

11. Predicting Effects of Environmental Change on a Migratory Herbivore

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Changes in climate, food abundance and disturbance from humans threaten the ability of species to successfully use stopover sites and migrate between non-breeding and breeding areas. To devise successful conservation strategies for migratory species we need to be able to predict how such changes will affect both individuals and populations. Such predictions should ideally be process-based, focusing on the mechanisms through which changes alter individual physiological state and behavior. In this study we use a process-based model to evaluate how black brant (*Branta bernicla nigricans*) foraging on common eelgrass (*Zostera marina*) at a stopover site (Humboldt Bay, USA), may be affected by changes in sea level, food abundance and disturbance. The model is individual-based, with empirically-based parameters, and incorporates the immigration of birds into the site, tidal changes in availability of eelgrass, seasonal and depth-related changes in eelgrass biomass, foraging behavior and energetics of the birds, and their mass-dependent decisions to emigrate. The model is validated by comparing predictions to observations across a range of system properties including the time birds spent foraging, probability of birds emigrating, mean stopover duration, peak bird numbers, rates of mass gain and distribution of birds within the site: all 11 predictions were within 35% of the observed value, and 8 within 20%. The model predicted that the eelgrass within the site could potentially support up to five times as many birds as currently use the site. Future predictions indicated that the rate of mass gain and mean stopover duration were relatively insensitive to sea level rise over the next 100 years, primarily because eelgrass habitat could redistribute shoreward into intertidal mudflats within the site to compensate for higher sea levels. In contrast, the rate of mass gain and mean stopover duration were sensitive to changes in total eelgrass biomass and the percentage of time for which birds were disturbed. We discuss the consequences of these predictions for black brant conservation. A wide range of migratory species responses are expected in response to environmental change. Process-based models are potential tools to predict such responses and understand the mechanisms which underpin them.

12. Emigration of sympatric Ross's and Snow Geese from the central North American Arctic: the roles of prior breeding success, environmental conditions and abundance

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Emigration is one of the most difficult demographic rates to estimate, yet movement among populations has important consequences for individual fitness and population dynamics. We studied emigration and the factors affecting it for Ross's geese (*Chen rossii*) and lesser snow geese (*Chen caerulescens caerulescens*); data were from a long-term study of geese nesting at the Karrak Lake colony (1997-2013), or captured in the associated brood-rearing area south of Queen Maud Gulf in the Central Canadian Arctic. Burnham's model was used with live recapture and dead recovery data to estimate true survival and fidelity, i.e., the complement of emigration. Mean estimates of fidelity were higher for Ross's geese (male = 0.91 $\pm$ 0.02, female=0.95 $\pm$ 0.01) than for snow geese (male=0.76 $\pm$ 0.02, female=0.90 $\pm$ 0.02). Fidelity was lower following years of higher abundance for both species but the long-term increase in the population resulted in only a slight decline in fidelity for Ross's geese and male snow geese. Fidelity was positively influenced by nest success in the previous year. As annual mean nest success varied from 0.69 to 0.93, fidelity of female Ross's geese increased from 0.80 to 1.0. Female snow goose fidelity changed from 0.80 to 0.97 as annual nest success increased from 0.60 to 0.88. We expected that higher snow cover would lead to greater emigration out of the Queen Maud Gulf region as individuals sought breeding sites in less snow covered areas. However, we found the opposite effect with higher fidelity in years of greater snow depth, suggesting individuals return to the site regardless and may be discouraged from dispersing across a snow covered landscape. We also tested whether a rapid decline in the number of snow geese nesting at Karrak Lake in 2007-2008 was related to a mass emigration event but found no evidence for a change in fidelity in these years relative to the period before and after the decline. Moreover, survival of both species steadily increased from 1997-2013. Therefore, we suspect that the cause of the decline was most likely due to a larger proportion of the population entering the non-breeding component.

13. Midcontinent greater white-fronted goose distribution and migration chronology: A study using advanced satellite telemetry

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Midcontinent population of greater white-fronted geese (*Anser albifrons*) have gained considerable attention from resource managers in recent years given the recognized increase in population abundance and perceived shift in wintering distribution from the Central to the Mississippi Flyway. Given changes in land use practices and winter water availability, the distribution of wintering midcontinent white-fronts is changing and warrants further investigation. Currently little is known about the patterns of space use by midcontinent white-fronts. The objectives of this research are to document annual migration chronology and provide utilization distribution models of winter habitat selection of midcontinent white-fronts using Argos compatible, solar-powered Platform Transmitter Terminal (PTTs) transmitters. We deployed PTTs on 10 non-breeding or failed nesting white-fronts during 13-14 July 2014 in conjunction with the Canadian Wildlife Service's Perry River white-front banding operation in the Queen Maud Gulf, Nunavut, Canada. Seven PTT marked white-fronts departed the molting areas in Nunavut between 1-9 September, 2014. White-fronts flew non-stop and arrived on staging areas in Saskatchewan and Alberta within two days of departure. All living PTT white-fronts were in the Alberta and Saskatchewan survey region during at the time of the fall aerial inventory survey. Marked white-fronts remained on the staging areas for a mean stopover of 54 days with departure dates ranging from 24 October-4 November 2014. Five transmitters are still active on the wintering grounds. Results from this study will inform managers what proportion of PTT marked midcontinent white-fronts are staging in Alberta and Saskatchewan and their position in relation to the flight path of the fall inventory at the time of the survey. In regards to winter foraging habitat selection, these data may be used to refine energetic models that assume wintering white-fronts are foraging in flooded agricultural field 25% of the time.

14. Building a Predictive Model of Submerged Aquatic Vegetation Prevalence for Atlantic Brant Using Remote Sensing and In Situ Sampling

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Atlantic brant (*Branta bernicla hrota*) are among very few species that are dependent on presence of submerged aquatic vegetation (SAV) as their primary food source. This submerged aquatic vegetation, specifically *Zostera marina* (eelgrass) and macroalgae (*Ulva sp., Entermorpha sp.*) has been found primarily in intertidal areas along the east coast of the United States, which is also the wintering habitat for brant. Because of the specialized location of SAV production and the specialized consumption by brant, it would be beneficial to determine the current availability of SAV for estimating brant carrying capacity. Using arcGIS and Landsat imagery, a simplified model was created to produce initial sampling locations along the intertidal areas of New Jersey. The points are then sampled during the winter of 2015 at low tide for presence of SAV, the vegetation types present, water turbidity and depth, and their dry weight which can then be used to estimate energy availability. Joined with previous estimates of daily energy expenditure, this data will allow us to estimate local carrying capacity. This baseline data will then be used, along with higher resolution multi-spectral aerial imagery to produce a model to predict areas of SAV presence along the Northeast and Mid-Atlantic intertidal region, as well as additional sample areas to determine the accuracy of the methodology used. This will result in a better understanding and estimation of the amount of SAV available and the amount of Atlantic brant that can be supported by these areas, thus aiding future population and habitat management decisions.

15. Activity Budgets of Black Brant on the Alaska Peninsula during Winter and Spring

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Staging and migrating black brant (*Branta bernicla nigricans*) have one of the most specialized diets of geese, utilizing coastal habitats to feed primarily on intertidal eelgrass (*Zostera marina*) during the non-breeding and pre-breeding seasons. Past studies suggest that black brant may not reach daily energetic requirements given limited access to eelgrass meadows which are covered each day during a typical tide cycle. Given this foraging constraint, black brant may utilize other methods to acquire enough nutrients, such as searching for and consuming drifting eelgrass during ebb, flood, and high tides (drift foraging), and foraging on eelgrass at night when tides are unfavorable during daylight periods (nocturnal foraging). Increasing numbers of black brant are wintering in Alaska due to climate warming, which has resulted in an increase in eelgrass availability due to less shore-fast ice, and decreased thermoregulatory requirements. Eelgrass meadows are reachable by brant when tides are less than 0.9 m of mean lower low water, (5.3 hr/day in winter, 11.7 hr/day in spring), which influences the activities they may perform during tidal cycles. The objective for this study was to quantify time-activity budgets during different tidal conditions for black brant in Alaskan habitats during winter and spring. I performed instantaneous flock scans to determine daily activity budget during winter (February-March) in Kinzarof Lagoon, and during spring (April-May) in Izembek Lagoon. Separate scans were performed for flight time budgets, which were joined to the other scans to calculate a more accurate diurnal activity budget for black brant. On average over all months and tidal stages, black brant were engaged most in vigilant behaviors, then foraging, comfort, and locomotion behaviors. Brant were more vigilant in winter than spring, foraged more in spring than winter, with no difference in comfort, locomotion, and flight activities between seasons. Having this understanding of black brant activity budget allows us to better understand and determine their ecological requirements during winter and spring. Future research could explore the conditions leading to nocturnal foraging, which would enhance our understanding of how black brant survive winter in Alaska, and exceed daily energy expenditure in order to reproduce.

16. Evaluating the Large-Scale Effects of Geese on Other Tundra-Nesting Birds

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In some areas, populations of arctic geese are causing significant change to their breeding and staging habitats. These habitat changes could impact other sympatric birds. Overgrazing by geese weakens vegetation and grubbing of roots impedes regrowth. These pressures can result in a habitat with shorter grass/sedge or exposed sediment, providing less cover for birds that require vegetation to conceal nests from predators. Goose colonies may also be attracting generalist predators such as Arctic Foxes (*Vulpes lagopus*), which could lead to a locally elevated risk of predation for other birds. Shorebirds are a diverse taxon in Arctic habitats and many species use well-vegetated coastal habitats and concealed nest sites. Many populations of arctic-breeding shorebirds are declining, possibly in part due to goose-induced habitat alteration. My research seeks to evaluate the effects of Midcontinent Lesser Snow (*Chen caerulescens caerulescens*), Tallgrass Prairie Cackling (*Branta hutchinsii*), and Ross' (*Chen rossii*) Geese on other tundra-nesting birds. Working at two sites in the Eastern Arctic with varying degrees of goose abundance and habitat damage, we are carrying out ground-based and remotely-sensed assessments of habitat change and linking change to habitat preferences of shorebirds. We are evaluating numerical and functional responses of predators to the presence of breeding geese, and linking these responses to shorebird nest depredation rates through the use of trail cameras. Using shorebird surveys carried out across the Canadian Arctic (PRISM), we relate density and community composition of shorebirds to the distribution of breeding and staging geese. The dramatic increases in the abundance of geese in the Eastern Arctic and concurrent declines of shorebirds in this region suggest at least the potential for an issue of conservation concern. My research should provide information on whether and how geese might affect other tundra-nesting birds, so that goose management can acknowledge the needs of these other bird populations.

17. Body condition of lesser snow (*Chen caerulescens caerulescens*) and Ross's Geese (*C. rossii*) harvested by different methods during the Light Goose Conservation Order.

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Despite the liberalizations of hunting regulations and the implementation of a conservation order for the past 16 seasons, current efforts appear ineffective in reducing light goose populations. One factor potentially contributing to continued population growth may be the inadvertent selection of poorer conditioned birds more vulnerable to common harvest tactics, thereby limiting the impact of sustainable population reduction. The goal of this study was to examine potential differences in body condition of hunter harvested light geese and geese from the general population that might provide insight for harvest management. Light geese were opportunistically collected by hunters and researchers in the Nebraska Rainwater Basin during the spring 2012 and 2014 Light Goose Conservation Order. Body mass (kg), wing chord (mm), tarsus (mm), middle toe (mm), head length (mm), and culmen (mm) measurements were collected from the harvested geese. Light geese were classified by age (adult vs. juvenile), collected landscape features where harvest occurred (public vs. private ownership; harvest over land vs. over water), and harvest technique (decoyed vs. jump shot). We regressed a principle components analysis based on morphological characteristics against recorded body mass to obtain a size adjusted body mass. A Student's t-test was used to determine if differences existed in adjusted body mass between age class, harvest technique, landscape, and ownership for both snow and Ross's geese. Combined data from both years revealed snow geese harvested over decoys were in poorer condition (mean = 1,707g; n=60) relative to jump shot snow geese (mean = 2,220g; n=79; $P < 0.0001$). Snow geese harvested over land were also in poorer condition (mean = 1,654g; n=46) than snow geese over water (mean = 2,130g; n=94; $P < 0.0001$). Ross's geese (n=16) showed no body condition differences between any of the factors evaluated. Results of this study suggest harvest over decoys, the primary form of hunter harvest, disproportionately selects for poorer conditioned birds and leads to further questions about the efficacy of the conservation order to sustainably reduce population size. The present findings have led to an expanded project to begin during the 2015 conservation order evaluating proximate body condition of light geese harvested over a larger geographical area (Arkansas, Missouri, Nebraska, and South Dakota) by similar harvest techniques used in this study. Additional objectives include determining breeding origin of harvested geese to examine the flock composition available to hunters relative to breeding demographics of the overall population.

18. Are snow geese affecting other birds? Comparisons of condition, hematocrit, egg volume, clutch size and nest success of arctic-breeding shorebirds on two Arctic islands with and without snow geese

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Shorebird populations in arctic North America have declined significantly over the last 40 years. Simultaneously, arctic-breeding lesser and greater snow geese (*Chen caerulescens caerulescens, C.c. alanticus*, respectively) have increased dramatically from estimates of ~120,000 birds in 1965 to estimates of over 15 million in 2011. Overabundant snow geese breeding sympatrically with shorebirds might play a role in their population declines. The high densities of snow geese at a number of locations in the Arctic are hypothesized to negatively impact shorebirds' breeding success through either direct physical goose presence and/or indirect-related effects from habitat degradation from over-grazing and attracting predators. However, there is currently little empirical evidence with which to compare the relative importance of these mechanisms of interaction. Two islands north of Hudson Bay, Southampton and Coats Island, Nunavut, provide a perfect opportunity to study these effects because one site is heavily used by breeding snow geese while impacts of geese are minimal at the other. To determine how individual shorebirds are responding to habitat degradation and physical disturbances from snow geese, we asked how a shorebird might be physiologically compromised by the direct presence of snow geese as a result of disturbance. We evaluated differences in body condition (total body weight), hematocrit, egg volume and clutch size between sites with and without goose disturbance, and also assessed differences in blood parasites that indicate a suppressed immune system. We predicted that breeding shorebirds nesting on Southampton Island would demonstrate physically compromised body condition via decreased body mass, egg volume and clutch size, with increases in parasitic infection prevalence compared to Coats Island where snow geese are virtually absent. Shorebird nests were monitored on both islands during the breeding season on two remote field sites. Incubating birds were captured and processed while eggs were measured and photographed. Nests were monitored until fail or hatch during early June to the end of July. A principal component analysis compared each parameter for breeding shorebirds on both islands. Resulting principal components were used to determine if these parameters can help determine nest success and whether or not nest success differed between Southampton Island compared to Coats Island. Assessing the direct and/or indirect significance of goose-related impacts on shorebirds will be essential in understanding some of the long term consequences of impaired body condition, reproductive success and survivorship of declining shorebirds.

19. A Preliminary Assessment of the Role of Interior Spring Staging Areas and Acquisition of Berries in Influencing Pre-Breeding Condition of Cackling Geese on the Yukon Delta NWR

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Perplexing results published by Raveling (1979) revealed that female cackling Canada geese (*Branta hutchinsii minima*) showed a 50 percent gain in body mass upon arrival on the coastal nesting areas of the Yukon-Kuskokwim Delta, as compared to female geese collected at the "last" identified spring staging sites in north-east California. Despite substantial research efforts no satisfactory answer has resolved this discrepancy or identified where cackling geese are acquiring excess nutrients in transit to the YKD coast. In theory high lipid plants are avoided by migratory birds early in spring migration due to the burden of additional mass, however once geese reach more northern latitudes the additional burden may not be as high and may actually be necessary for follicle development prior to initiation. The lack of sufficient data on the use of interior regions of the Yukon Delta NWR and high numbers of harvested geese from interior regions exhibiting evident vent staining from berries, led us to hypothesize that interior overwintering berries may play a more significant role in reproduction than originally believed. With the use of Stable Isotope Analysis (SIA) we sought to assess the role of overwintering berry crops and their overall contribution in pre-nesting nutrient acquisition. We collected samples of several berry species prevalent on interior and coastal landscapes to create a reference collection of this available overwintering nutrient resource. Additionally, adult geese were harvested during the spring migration by subsistence hunters, we solicited voluntarily donated abdominal fat and liver samples to correlate C:N ratios to the reference values of the sampled berries. We present preliminary findings from our efforts and future steps needed to finally arrive at a satisfactory answer to an age-old mystery.

20. Assessing Competition by Cackling Geese and Lesser Snow Geese on Breeding Atlantic Brant

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The most recent mid-winter surveys suggest Atlantic brant (*Branta bernicla hrota*) populations are suffering their lowest numbers in over 30 years. While brant populations are known to fluctuate, productivity surveys on the wintering grounds indicate the number of young in flocks has declined in recent decades. This may be indicative of a limitation on the breeding grounds. Expanding populations of lesser snow geese (*Chen caerulescens caerulescens*) and cackling geese (*Branta hutchinsii*), utilizing the same breeding grounds, may be contributing to the decline in brant breeding success. Identifying all forms of interspecific competition among brant and these other arctic nesting goose species is key to understanding any possible limitations that may be occurring. Southampton Island has historically supported a breeding population of Atlantic brant; however, the number of breeding brant on the island decreased significantly in the last 30 years. The island also supports populations of nesting lesser snow geese and cackling geese. We studied the interactions occurring between brant, snow geese, and cackling geese on the coast of East Bay, Southampton Island in the summer of 2014. We used careful monitoring of behaviors, time budgets, reproductive success, and foraging habitats where the breeding of these three species overlaps in order to establish if pre-emptive, interference, exploitative, or apparent competition is occurring between snow geese, cackling geese, and Atlantic brant, thereby reducing brant reproductive success. As Atlantic brant populations have experienced long-term fluctuations, efforts to understand their limitations have focused on the wintering grounds. However, as lesser snow geese and cackling geese populations continue to grow and exert potentially direct or indirect competitive pressure on the brant breeding grounds, it is critical for future management to quantify the presence and strength of such a possible limitation.

21. Do individual heterogeneity and age structure limit the reproductive potential of goose populations?

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The black brant (Brant bernicla nigricans) is a small, arctic nesting goose, occurring in coastal estuaries and wetlands along the Pacific coast. Brant populations on the Yukon-Kuskokwim Delta have declined substantially since the 1980's, and the population remains significantly below historic levels. A study of brant population ecology was initiated in 1984 at the Tutakoke River Brant Colony (hereafter, TRC), to better understand the causes of this decline. Since the project's inception, >45,000 individual brant have been marked with unique tarsal bands. We used linear mixed-effects model to analyze nesting data collected at TRC from 1994-2013, to better understand age and individual effects on reproductive success. We included 1,959 nests laid by 983 unique, known-age females, in analyses. Reproductive success varied quadratically with female age, and individual random effects were significant in reproductive investment models. These findings are congruent with previous research, which indicated individual and age effects on black brant breeding propensity and survival, and indicate that large nesting failures may affect future colony reproductive potential.

22. Ecological effects on midcontinent light goose recruitment

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Adult survival probability in Ross's geese (*Chen rossii*) and midcontinent lesser snow geese (*Chen caerulescens caerulescens*) has remained high (>0.80) despite reduction efforts implemented in 1999 with a spring conservation order designed to increase harvest of light geese. Population growth rate of lesser snow geese may be attenuating, and with no concurrent decline in adult survival probability, the attenuation must be an outcome of reduced recruitment. A decline in the age ratios (immatures/adults) of Ross's and lesser snow geese has been observed in August at central arctic brood-rearing areas during banding, as well as on prairie staging areas later in the fall. Recruitment is an outcome of various transition probabilities leading to adulthood, any of which could be influenced by ecological proximal factors (e.g. nutrient reserves, spring phenology) or regulating mechanisms (i.e. density dependence) potentially with direct or indirect effects on annual productivity. My study aims to estimate the relative contribution of factors that influence the per capita production of fledged goslings in populations of Ross's geese and midcontinent lesser snow geese. The study area includes brood-rearing areas near the Karrak Lake goose colony (67° 14' N, 100° 15' W) located within the Queen Maud Gulf Migratory Bird Sanctuary, Nunavut, Canada. Long-term data for nest initiation date, clutch size, nest success collected (1991-2015) at the colony using nest plot surveys and banding drives, pre-nesting body composition of females arriving to nest at Karrak Lake, climate indices and local weather will be employed to model retrospectively the response in August age-ratios – a metric of per capita recruitment until fledging. This research will provide insight about current population trajectories and the relative contributions of recruitment vs survival in governing annual variation in abundance of both Ross's and midcontinent snow geese.

23. Should I stay or should I go? Fitness costs and benefits of prolonged parent-offspring and sibling-sibling associations in an Arctic-nesting goose population

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Theory predicts persistence of long-term family relationships in vertebrates will occur until perceived fitness costs exceed benefits to either parents or offspring. We examined whether duration of parent-offspring and sibling-sibling relationships increased lifetime breeding probability and survival in a long-lived Arctic migrant herbivore, the Greenland White-fronted Goose (*Anser albifrons flavirostris*). Although offspring associated with parents 1-13 years, most (79%) relationships lasted two or less years. Only 65 (9.9%) of 656 marked offspring bred once in their lifetime and just 16 (2.4%) bred twice or more. Breeding probability increased little dependent on years with parents, but dramatically and non-linearly dependent on years with sibling(s) and post-independence, i.e. oldest birds achieved greatest breeding probabilities regardless of time with family. Bayesian multistate survival models showed no significant difference in age-specific survival between birds with parents/siblings and those independent. A cost-benefit model showed that departure from family groups was marginally favoured over the 'stay' strategy at all ages. Although extended family associations are a feature of this population, we contend that they are relatively uncommon, do not have clear fitness benefits and may persist because parents and (poor quality) offspring mutually benefit from their persistence.

24. Aerial Detection of Incubating Geese in an Open-Tundra Habitat

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We estimated aerial detection rate of nesting geese by comparing aerial counts of indicated breeding pairs of cackling geese (*Branta hutchinsii*) and brant (*Branta bernicla*) to ground-based counts of nests in arctic tundra habitat. Ground surveys were conducted on foot by two observers between June 24 and 28, and all nest locations were identified to species and recorded using a Global Positioning System (GPS). Only nests known to be active on the day of the aerial survey were included in air-ground comparisons. Aerial surveys were flown on June 29, 2010 in a Quest Kodiak fixed-wing airplane at approximately 45 m AGL and a speed of approximately 145-170 km/hour. All geese within 200 m of each side of the aircraft were tallied as singles, pairs, or groups of varying size by the pilot and right seat observer, and birds were denoted as either flying or stationary on the ground/water. Each observation was recorded vocally to a file that was simultaneously linked to a GPS coordinate. Birds counted as singles and pairs were assumed to represent a pair, and groups of 3 or 4 birds were assumed to represent two pairs; larger groups were assumed to represent non-breeding geese and were eliminated from consideration. We used ArcGIS to plot all nest locations aerial observations, and to compare the number of active nests to the number of indicated breeding pairs where the two surveys overlapped. Within the 400m-wide survey transect, there were 143 active cackling goose nests, and 32 active brant nests on the day of the aerial survey. Aerial survey observations included 31 indicated breeding pairs of cackling geese and 12 indicated breeding pairs of brant. Detection rate for cackling geese was 0.22, and for Atlantic brant was 0.38. Of all birds observed from the air, 91% of detected cackling geese were flying, and 100% of detected brant were flying. This suggests that flying birds were easier to detect than those that remained on the ground, and that birds that remained on the ground were largely undetected. Alternatively, nesting birds could have flushed in advance of the plane's arrival, resulting in low detection. We caution that aerial survey estimates of open-tundra nesting geese that do not account for detection probability may greatly underestimate numbers of geese, even in open habitats under ideal survey conditions.

25. Assessing Habitat Change at East Bay, Southampton Island: 1979 to 2010

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Goose populations subsidized by southern agricultural foods have caused habitat damage on their staging and breeding grounds in the subarctic and arctic. However, few studies have been able to use empirical data to assess habitat change on arctic breeding areas. We sought to assess habitat conditions and change at East Bay, Southampton Island, a site where significant population increases of snow and cackling geese have occurred since the 1970s. Georeferenced estimates of % ground cover within 1m of the nest were available from nesting ecology studies conducted in 1979 and 2010. The % ground cover for different cover types were interpolated using a natural neighbor interpolation (ArcMap v10.1). The resulting surfaces were compared to assess habitat change. Primary forage species (sedges) have declined dramatically throughout the study area. A decline of lichen, moss and to a lesser extent *Dryas integrifolia* on inland ridges has resulted in an increase in bare ground and rock in these habitats while moss appears to be increasing in some previously bare areas.